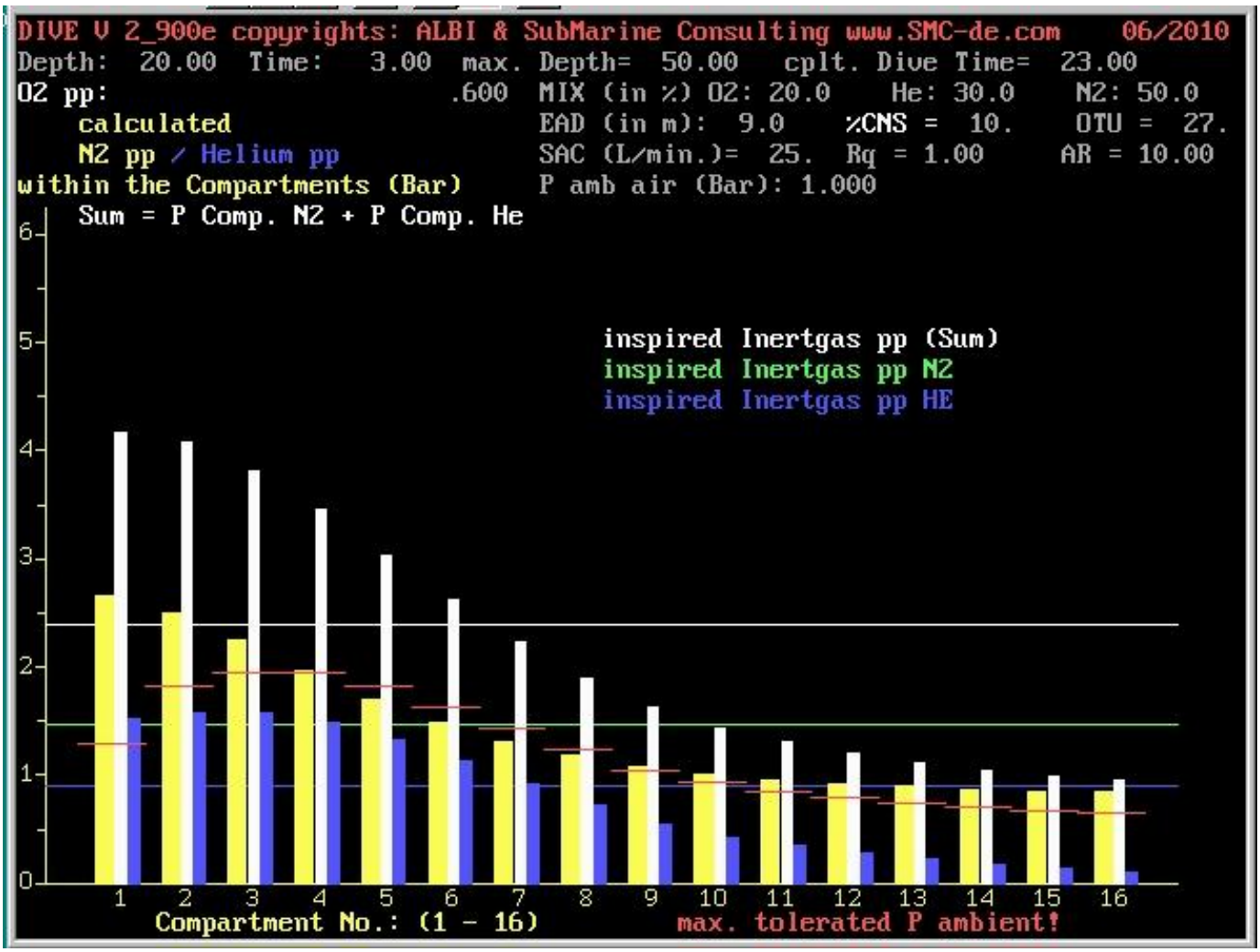
DIVE V 2_901_e Manual Version 2012 / 2013



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Documentation for „DIVE“ Version 2_901_e 06/2010

Contents

1 Quick Start

Simulation of a deco dive:
after download and un-packing the DIVE Version 2_9 ZIP archive: double click in the explorer on:
"D2_901_e.exe" or:
you open a DOS compatibility box via :”Start” -> “Execute” -> “CMD” or “COMMAND”;
at the prompt of the DOS box you key in: "D2_901_e.exe"
The example is: a dive on air, depth 42 meter, bottom time 21 minutes:
“What now?” "d" "42." "21"
We get the following:

```
what now? D

Input of DIVING DEPTH in meter & cm:(m.cm): 42.

Input of DIVE TIME in minutes (min): 21

 P amb:  5.200 P insp N2:  4.058 P insp He:   .000

 max. Depth=  42.0 cplt. Dive Time=  21.00 cur. Depth:  42.0 m cur. Time:  21.00

 - - - - - - - - - - - - - - - - - - - - - - - -
 Nr.:  1 3.97 P N2  .00 P HE Sum.=  3.97 Ceil. m=  3.70 Putol:  1.37
 Nr.:  2 3.53 P N2  .00 P HE Sum.=  3.53 Ceil. m=  6.47 Putol:  1.65
 Nr.:  3 3.04 P N2  .00 P HE Sum.=  3.04 Ceil. m=  5.72 Putol:  1.57
 Nr.:  4 2.57 P N2  .00 P HE Sum.=  2.57 Ceil. m=  4.19 Putol:  1.42
 Nr.:  5 2.15 P N2  .00 P HE Sum.=  2.15 Ceil. m=  2.45 Putol:  1.24
 Nr.:  6 1.82 P N2  .00 P HE Sum.=  1.82 Ceil. m=  1.12 Putol:  1.11
 Nr.:  7 1.56 P N2  .00 P HE Sum.=  1.56 Ceil. m=   .00 Putol:   .97
 Nr.:  8 1.35 P N2  .00 P HE Sum.=  1.35 Ceil. m=   .00 Putol:   .85
 Nr.:  9 1.20 P N2  .00 P HE Sum.=  1.20 Ceil. m=   .00 Putol:   .75
 Nr.: 10 1.10 P N2  .00 P HE Sum.=  1.10 Ceil. m=   .00 Putol:   .69
 Nr.: 11 1.03 P N2  .00 P HE Sum.=  1.03 Ceil. m=   .00 Putol:   .66
 Nr.: 12  .98 P N2  .00 P HE Sum.=   .98 Ceil. m=   .00 Putol:   .64
 Nr.: 13  .94 P N2  .00 P HE Sum.=   .94 Ceil. m=   .00 Putol:   .62
 Nr.: 14  .91 P N2  .00 P HE Sum.=   .91 Ceil. m=   .00 Putol:   .62
 Nr.: 15  .88 P N2  .00 P HE Sum.=   .88 Ceil. m=   .00 Putol:   .61
 Nr.: 16  .86 P N2  .00 P HE Sum.=   .86 Ceil. m=   .00 Putol:   .61
```

afterwards: "a"
Next deco step:_
" "
(i.e.: no input, according to a depth = 0.0 m). We get immediately various suggestions for deep stops and a complete deco prognosis for each stage and the # of the leading compartment with the TTS (time-to-surface):

```
what now? A

maximal Ceiling:  6.47

Proposal Haldane 2:1 [m] =   15

Proposal Hills, B. A.: DEEP STOP [m] =   24

PDIS for TAU = 10 min:  32.23 [m]

PDIS for TAU = 20 min:  21.78 [m]

PDIS for TAU = 30 min:  16.22 [m]

Input of Ascent Stage Meter & cm (m.cm): 0

          Ascent Stage to near to surface:

          must be deeper than Ceiling!

 Deco Prognosis:
 9m Stop Prognosis Deco Time:   1.00  Comp.#:  2
 6m Stop Prognosis Deco Time:   4.00  Comp.#:  3
 3m Stop Prognosis Deco Time:  11.00  Comp.#:  6
TTS =   20.00
```

The little program is nagging because 0 is shallower than the allowed maximal ceiling of ca. 7 m: but that's just an information with no consequences!

So, that's it!

2 Motivation and Background-Infos

„DIVE" is a little software tool for simulating any multi-level dives with arbitrary depths & bottom-times and surface intervals and with optional mixes: the goal is to show the intermediate/advanced (*) diving student the internal procedures in a dive computer and why a dive table looks the way it looks. For this the output are long columns of raw data for each of the considered compartments and a plot output with bar charts. It does not control if an air dive to 200 m is too deep, or if an EAN with 98 % O2 is too dangerous beyond 6 m ... So it is up to you, to plan and simulate reasonable dives and compare the influence of changing a mix, various deep stop strategies and diverse decompression methods.

The source code is FORTRAN 77, compiled via MS/FTN-DOS Compiler V 5.1; the internal calculations are done with DOUBLE PRECISION (REAL * 8), so they are accurate up to the 14th or 15th bit. Due to the fact that the most widespread diving tables stem from the 70s or 80s and are normally calculated with a 8 bit technology there is already discrepancy for longer and shallower dives with newer desktop deco software using 16 or 32 bit technologies.

By default DIVE is using a standard ZH-L 16 algorithm. ZH means Zuerich, the town in Switzerland where Albert Alois Buehlmann worked, L is for linear due to the linear equations for the allowed supersaturations and 16 means the number of considered compartments. In detail it is the ZH-L 16C set of coefficients from 1985 which you will find documented for e.g. in [65] on page 158. You could change this set easily to a modern set from Dr. Max Hahn from 2000. This set is comparable to that one which was used to make the European DECO2000 table. As well there is an expert modus: there you could change all the values of the complete set, i.e. halftimes, A- or B-coefficients and as well per each compartment the gradient factors GF HI and GF LO, resulting in the new VGM, the so-called "Variable Gradient Method". This is possible for both N2 and HE, but in separate sets.

DIVE always shows the calculated values for all 16 compartments without truncation or rounding on/off: this is in contrast to every decompression table and to every dive computer display and to give you a feeling, what's going on there. Only in the dedicated simulations there is the rounding on in order that you could compare these figures with the tables you dive or the outputs from your equipment.

As well there are some features unique to DIVE: we have implemented deco prognosis/simulations according to:

- DAN/DSL the Diver's Alert Network / Diving Safety Laboratory, i.e. the PMRC method, the proportional M-value reduction concept
- PDIS (pressure dependant intermediate stops) from UWATEC/SCUBAPRO
- Security surcharges a la method COCHRAN, SUUNTO or MARES
- oxygen correction factors according to NMRI (the Naval Medical Research Institute)
- Asymmetric desaturation according to NEDU (the Naval Experimental Diving Unit)
- Right-to-Left shunt simulation according to Buehlmann and co-workers
- P(DCS): a tool for predictive calculation of the probability of decompression sickness via various methods

As well you could put across the ideas of ICD (isobaric counter diffusion), of oxygen pre-breathing or the adaption to a mountain lake with just a couple of simple inputs.

(*): a PADI / SSI Advanced (or similar like a CMAS ***) and a NITROX / EAN course would be helpful.

The tool uses approx. 160 kB RAM and works in any DOS-Box. We tested it against the following OS environments (06 / 2010):

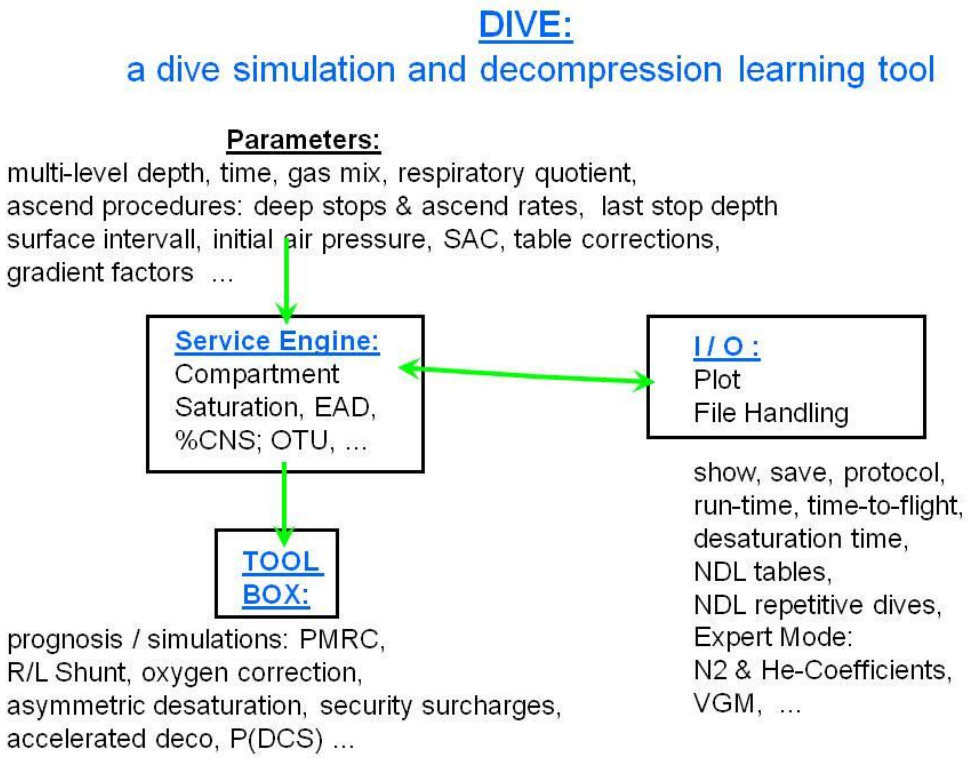
* DOS 6.2
* Win 95

* Win 98 (Version 4.10)
* Win 2000 (SP 4)
* Win XP (SP 2 und SP 3), Version 5.1.2600
* Parallels Desktop 5.0 under MAC OS X 10.6.3 (+)
* Windows 7 32 Bit Version 6.1.7600 (+)
* Virtual Box 4.0.2 v 69518 under UBUNTU 10.04 LTS
* Windows 7 **64 Bit**, 6.1.7601, all Versions with: DOSBox0.74 (++), (+++)

* Untested OS Environments:
* other Unix-Derivatives, x64 (++), (+++)
* for Win7 Professional and Win7 Ultimate there is as well an official tool from Microsoft, the „Windows Virtual PC“ for free under: http://www.microsoft.com/windows/virtual-pc/default.aspx

(+): with limitations at "P" resp. without “full screen” mode
(++) for free at: www.dosbox.com, products from SourceForge.net; for Win7 x64: ca. 4,5 MB
(+++) as well for free at: www.virtualbox.org, from Oracle: 4.0.12. ca. 80 MB

The basic inner workings of DIVE you could see in the following chart: the standard input for any multi-level dive (depths, times, mixes per each stage) gets the SERVICE ENGINE started and calculates the inertgas-saturation of the 16 compartments. Output, graphical or numerical presentation is done in the I/O building block. The TOOL BOX offers various simulation and prognosis tools, which do not change the data basis achieved with the service engine:



3 DISCLAIMER

Diese Software ist nur für Teilnehmer am PADI / SSI Specialty "DIVE TABLES", dem Spezialkurs für Tauchcomputer & Tauchtabellen, von Dipl. Phys. Albrecht Salm, PADI Master Scuba Diver Trainer Instructor # 33913, SSI Advanced Instructor & Technical Extended Range Instructor # 12653, oder für Kursteilnehmer an den SSI TXR Kursen oder Teilnehmern des „deco workshops“, gedacht.

Jegliche Gewährleistung und/oder Haftung die aus dem Gebrauch dieser Software, der damit produzierten Daten oder anderer Kursmaterialien resultiert, wird hiermit explizit ausgeschlossen. Mit dem Benutzen und/oder Kopieren dieser Software erklärst du dich automatisch mit den o.g. Ausschlüssen und

Verfahrensweisen einverstanden; andernfalls hast du sämtliches Material sofort zu löschen. Desweiteren hast du die Verantwortung für einen eventuellen Virenbefall selbst zu tragen.

As a matter of fact we appreciate any e-mails with feedback, error/bug reports or suggestions for enhancements (or even corrections for any translational/grammar or what-ever error ...)

4 Installation

After download and un-packing of the ZIP-archive you could start DIVE (the topical english release of Version 2_9 is : “D2_901_e.EXE“) immediately and without further installation! Pls. cf. Chapter “Quickstart”. You will miss just the legends on the x- and y-axes (x: compartment #, y: pressure), the run-times via the protocol-file and the access to the coefficient sets (called matrix).

If you want to have these features, just make a couple of new directories and move the appropriate files accordingly:

C:\DIVE\	new main directory
C:\DIVE\PROG\	directory for all EXE.files of DIVE, valid for all programme versions
C:\DIVE\LIB\	directory for the Fortran Graphics Font Library, TMSRB.FON
C:\DIVE\PROT\	directory for the run-times, i.e. the file PROTOCOL.TXT, and as well for the matrices N2COEFF.TXT for nitrogen and HECOEFF.TXT for helium. The protocol file will be created automatically if this directory already exists prior to start of DIVE.

- Hint: when you save the calculated compartment values (via command “F”) you could put these files here.
- Next hint: makes copies of the matrices, best with descriptive names, like: COEFF_ORG.TXT or COEFF_VGM.TXT or the like ...
- Another hint: when you think, the program is throttled or a calculation takes too much time:
- „CNTL“ „S“: stops a calculation or an output
- „CNTL“ „C“: cancels DIVE
- The MD5 check sum of the exefile is:
- **9defe0dc5b720d06944641704dd91740**

5 Conventions

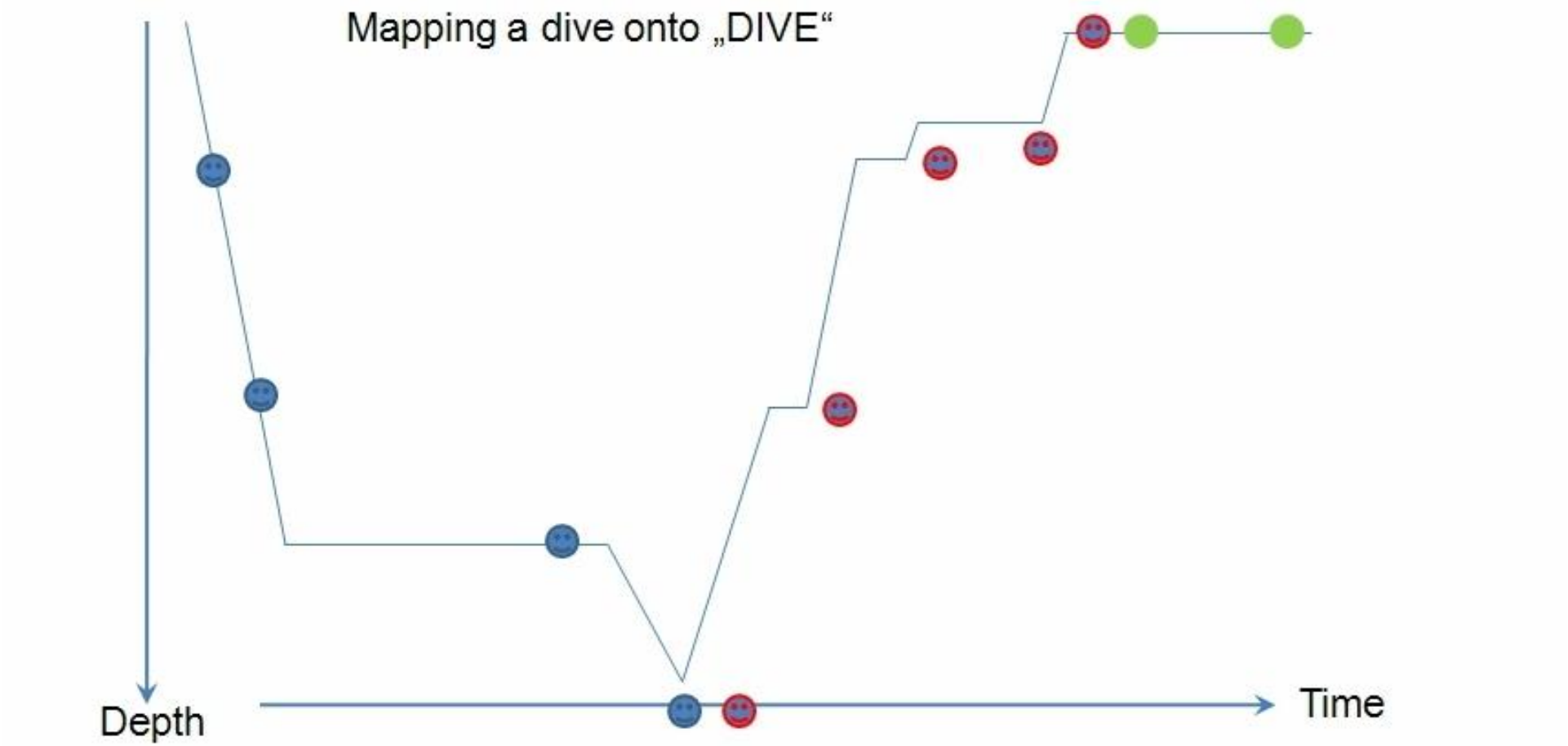
Commands / Inputs into DIVE or in the DOS Box are decorated with inverted commas here in this document for your convenience.
Xmp: we would like to make a deco stop at 4.5 m for 7 minutes: „e“ „4.5“ „7“

Air pressure is in mbar, depth in meters (fresh water) , time in minutes, fractions are naked numbers (dimensionless), %CNS is the percentage of the central-nervous oxygen toxicity dose whereas OTU is the absolute value.

With **Deco** we mean decompression as such, a deco stop, a deco pause or some other stage on the way back to the surface, **SI** is the surface interval, **SAC** is your Surface Air Consumption, with **Mix** we refer to any breathable gas mix, may it be air, nitrox, trimix or heliox..

The basic idea is to control the dive in every phase mathematically, in arbitrary, unlimited, small steps via a set of commands / inputs. This is more or less the same, how dive computers analyze a real dive. With

DIVE we can / could calculate standard rectangular box profiles, like a regular dive table. But there is more to it on the way down and up to get more information (pls. cf. the next chart):



Bottom Phase

Commands / Parameters, eg.:

„d“	10.0	1
„d“	20.	1
„d“	30.	10
„d“	45.	2

„a“ „p“ „z“ .....

Ascend Phase

Commands / Parameters, eg.:

„a“ 0.0

„ad“ „S“ „asy“ „oc“ „p“ „z“ „PMRC“ .....

deep stops: „a“ 27.5 or
„d“ 27.5 2

deco stops: „a“ stop depth < ceiling
„e“ next desired stop, stop time

„M“ for deco mixes

„V“ for reduced SAC during deco phases

Surface Interval

Commands / Parameters, eg.:

„o“ „T“ „N“ „RL“ „z“ „p“ „M“

„L“ for changed ambient air pressure

SI 3 h: „e“ 0.0 180 or
„d“ 0.0 180

next dive ->

6 The Instructions of Version 2_9 in Detail

After input of „D2_901_e.exe“ in the DOS-Box via (Start -> Execute -> "COMMAND") or (Start -> Execute -> "CMD") resp. a double-click on the DIVE-Icon in your Windows-Explorer you get the prompt for a comment. There you could enter any comment (or nothing) on the simulation / mission / plan your are doing. These comments would appear in the protocol file, the PROTOCL.TXT:

```
Comment:

           DIVE Version 2_901_e     06/2010 FTN 77
           copyrights: Dipl. Phys. "ALBI" A. Salm,
           PADI Master Scuba Diver Trainer #33913
           SSI Advanced & Technical Extended Range Instructor #12653
           & SubMarineConsulting: www.SMC-de.com

           Liability of any kind, may it be
           from the mere usage or the pure data
           of this software is hereby excluded !

 what now?
```

With: „what now ?” the program asks for commands. The basic commands may be entered in small or CAPITAL letters, followed by a RETURN / ENTER key. If there is s.th. wrong, the program reacts just with “Bunk”

The idea of the inputs is that the dive can be fragmented into small steps. The step-size related to the diving depth or the dive time is arbitrarily small (or big) as well is the number of steps unlimited. This yields especially for changes in the gas mix or your SAC. With the input of a question mark: “?” you will get:

```
  DIVE Version 2_901_e: 06/2010

 ?    = this Info File
 HELP = this Info File
 Q    = Program End (QUIT)
 EX   = Program End (EXIT)
 D    = D ive: Input of Depth and Time
 A    = A scend: Input of a staging depth
 E    = dE-saturation: calculation of deco time
 O    = c O mplete desaturation time & time-to-flight
 Z    = the actual ParameterZ- and Compartment-ValueZ
 F    = Filename for the Compartment-F ile
 N    = N DL for a repetitive dive
 T    = NDL - T ABLE: complete NoDecoLimits
 P    = P lot of the Compartmentvalues
 M    = MIX: Change of Breathing Gases
 V    = Change of SAC, 25 L/min.
 R    = R espiratory Quotient, 0.5 < Rq < 1.5
 L    = Ambient Air Pressure, xmp.: mountain L ake
 S    = S imulation of ascend strategies
 PMRC = Deco according DSL/PMRC
 NC   = N2 Coefficients
 HC   = HE Coefficients
 ASY  = ASY mmetrical desaturation
 OC   = O xygen C orrectionfactor
 RL   = R ight-/L eft Shunt
 B    = B uehlmann Tablecorrection
 LS   = L ast S top: depth of last stop 1.5 < LS <= 9.0 m
 GF   = G radient F actors GF Hi / Lo 0 < GF <= 1.0
 AR   = A scent R ate: 1.0 < AR < 100.0 m / min
 AD   = A ccelerated D eco: Decompression with EAN50, EAN75, EAN98
 MX   = runtime coefficient MatriX, only for mix gas
 PDCS = P(DCS), DCS Probability
 CLR  = CLeaR, Initialization of all Variables!
 !    = Back to DOS!
```

The somewhat cryptic mnemonics stem normally from german words resp. german abbreviations, thus follows a short explanation of the commands:

? or HELP	the above output
Q or EX	Program End (like QUIT or EXIT)
D	Start of the dive simulation (DIVE), input of diving depth in meter (Nota bene, in: m.cm) and dive time (in minutes)
A	Ascent: input of the next staging depth. Which should be deeper than the allowed ceiling.
E	Desaturation: calculation of deco times, input of a desired deco stage depth
O	Surface Intervall: output of complete desaturation time and time-to-flight (all per compartment)
Z	Shows the actual values for all the 16 compartments
F	Filename for the file of the above cited compartment values, this is not the dive protocol file
N	NDL for a single repetitive dive to a certain depth
T	TABLE: complete table with No-Decompression-Limits for a certain mix in the depth range from 6 - 63 m, with the usual 3m-spacing
P	Plot of the inert gas profiles: a graphical presentation of the calculated compartment saturations
M	MIX: change of breathing gas mix, input of oxygen fraction and then the helium fraction
V	SAC default = 25 L / min. Change it here
R	respiratory quotient Rq, 0.5 < Rq < 1.5
L	change of ambient air pressure (eg.: mountain lake diving)
S	Simulation of various deco scenarios: conservativism factors and security surcharges in percent
PMRC	Deco-Prognosis according the PMRC idea
NC	Expert-Mode: change of the N2-Coefficient-Matrix (TAU, A, B) and, as well per compartment the gradient factors GF HI and GF LO
HC	dito, as above, but for helium
ASY	asymmetrical desaturation according to U.S.Navy NEDU at depth and during SI
OC	Oxygen Correction: these factors are according to NMRI, at depth and during SI
RL	Right-/Left Shunt correction, only during SI
B	Buehlmann table correction procedure
LS	Last Stop: 1.5 < LS < 9.0 m
GF	Gradient Factors: both the GF HI and GF LO with: 0 < GF <= 1.0, and GF HI > GF LO!
AR	Ascent Rate: 1 < AR < 100 m/min (for apnea)
AD	accelerated deco: an automated prognosis with EAN50, EAN75 and EAN98 according to their respective MOD at ca. 1.6 Bar pO2
MX	Matrix: for the mix gas calculations; the weighted values, valid for the topical run-time
PDCS	Assessment of the P(DCS) = Probability of Decompressionsickness via various methods
CLR	CLeaR: all variables and compartment values are put to their defaults
!	back to DOS, a secondary Command-Processor is envoked. With „EXIT“ you leave again DOS and fall back to the DIVE program where you left it

You can not input all the commands at every stage of the dive. For eg.: "T", "N" or "RL" doesn't make any sense during diving, only during SI. And vice versa is "S" or "PMRC" during SI pointless. DIVE does not react at all in these cases.

At the end of DIVE there is the nice and friendly reminder of the inherent error in ALL calculations stemming from measured values through the law of error-propagation:

```
 what now? Q

See you later alligator

Always keep in mind the "10 % Bug" of your divecomputer!
Stop - Program terminated.
```

7 NDL Tables (Air and NITROX / EANx)

A simple exercise are NDL tables with various mixes via “T”: first we make a simple air table, then we set the Buehlmann correction factor in order to compare with the printed tables and then we make an EAN36 table, aka NN36 or NOAAII:

```
 what now? T
 6.0 m: ***** min.    9.0 m: 704.0 min.  12.0 m: 174.5 min.  15.0 m:  87.0 min.
18.0 m:  57.7 min.  21.0 m:  39.6 min.  24.0 m:  28.0 min.  27.0 m:  21.0 min.
30.0 m:  16.1 min.  33.0 m:  13.2 min.  36.0 m:  11.3 min.  39.0 m:   9.5 min.
42.0 m:   8.0 min.  45.0 m:   6.9 min.  48.0 m:   6.1 min.  51.0 m:   5.5 min.
54.0 m:   5.0 min.  57.0 m:   4.6 min.  60.0 m:   4.3 min.  63.0 m:   4.0 min.

 what now?  B

 Buehlmann Table Correction is set!

 6.0 m: ***** min.    9.0 m: 361.0 min.  12.0 m: 124.5 min.  15.0 m:  70.4 min.
18.0 m:  47.7 min.  21.0 m:  32.8 min.  24.0 m:  23.9 min.  27.0 m:  17.7 min.
30.0 m:  14.1 min.  33.0 m:  11.9 min.  36.0 m:  10.2 min.  39.0 m:   8.4 min.
42.0 m:   7.2 min.  45.0 m:   6.3 min.  48.0 m:   5.6 min.  51.0 m:   5.1 min.
54.0 m:   4.7 min.  57.0 m:   4.3 min.  60.0 m:   4.0 min.  63.0 m:   3.7 min.

what now? M

Input of Oxygen fraction, fO2:
as decimal number (Xmp.: 40 Vol.% O2 = 0.4) .36

Input of Helium Fraction, fHe:
as decimal number (Xmp.: 35 Vol.% HELIUM = 0.35) 0.0

fO2:  .360 fHe:  .000 fN2:  .640

 what now?  T

 6.0 m: ***** min.    9.0 m: ***** min.  12.0 m: ***** min.  15.0 m: 336.1 min.
18.0 m: 140.3 min.  21.0 m:  83.7 min.  24.0 m:  60.5 min.  27.0 m:  44.2 min.
30.0 m:  33.3 min.  33.0 m:  25.6 min.  36.0 m:  20.2 min.  39.0 m:  16.3 min.
42.0 m:  13.8 min.  45.0 m:  12.1 min.  48.0 m:  10.7 min.  51.0 m:   9.2 min.
54.0 m:   8.0 min.  57.0 m:   7.1 min.  60.0 m:   6.4 min.  63.0 m:   5.9 min.
```

from 6 – 63 m, without control for the MOD! A real dive table will round these numbers down, sometimes even more to the next smaller integer. As well there is a substantial distinction between these plastic things you could take along a dive and when you calculate it, may it be via a dive computer or a desktop deco software: the rationale is that for the tables we have only finite, big steps timewise speaking. Whereas for computers / deco software: not. This is why you will find 3 (three) sets of ZH-L coefficients in [65] on page 158, called A, B and C. Here, in DIVE, we have implemented the set called „C“ for dive computers.

8 Simulation of a NDL dive

Well, my late friend and former dive student, Dr. Bernd Aspacher, founder of a german TEC-organisation once said during a TEC conference in germany: **„NDL dives do not exist!“ (ל ’ ר, G-Tech Konferenz 16.11.2002, Esslingen)**

And I said thirty years ago in Elat / Israel when the local diving instructors were gazing at my brand-new DECO BRAIN: **Every dive is a decompression dive!**

But besides that we adhere here to the common usage of these words ... So let’s simulate this NDL dive to 17 m for 55 minutes. The ceiling is 0, so after: "d", "17.0", "55" you could proceed directly to the surface via “A”:

```
what now? D

 Input of DIVING DEPTH in meter & cm:(m.cm): 17.

 Input of DIVE TIME in minutes (min): 55

 P amb:  2.700 P insp N2:  2.083 P insp He:   .000

 max. Depth=  17.0 cplt. Dive Time=  55.00 cur. Depth:  17.0 m cur. Time:  55.00

 - - - - - - - - - - - - - - - - - - - - - - - - -
 Nr.:  1 2.08 P N2  .00 P HE Sum.=  2.08 Ceil. m=   .00 Putol:   .42
 Nr.:  2 2.07 P N2  .00 P HE Sum.=  2.07 Ceil. m=   .00 Putol:   .70
 Nr.:  3 2.02 P N2  .00 P HE Sum.=  2.02 Ceil. m=   .00 Putol:   .84
 Nr.:  4 1.92 P N2  .00 P HE Sum.=  1.92 Ceil. m=   .00 Putol:   .91
 Nr.:  5 1.77 P N2  .00 P HE Sum.=  1.77 Ceil. m=   .00 Putol:   .93
 Nr.:  6 1.61 P N2  .00 P HE Sum.=  1.61 Ceil. m=   .00 Putol:   .93
 Nr.:  7 1.44 P N2  .00 P HE Sum.=  1.44 Ceil. m=   .00 Putol:   .87
 Nr.:  8 1.29 P N2  .00 P HE Sum.=  1.29 Ceil. m=   .00 Putol:   .80
 Nr.:  9 1.17 P N2  .00 P HE Sum.=  1.17 Ceil. m=   .00 Putol:   .72
 Nr.: 10 1.09 P N2  .00 P HE Sum.=  1.09 Ceil. m=   .00 Putol:   .68
 Nr.: 11 1.03 P N2  .00 P HE Sum.=  1.03 Ceil. m=   .00 Putol:   .65
 Nr.: 12  .98 P N2  .00 P HE Sum.=   .98 Ceil. m=   .00 Putol:   .63
 Nr.: 13  .94 P N2  .00 P HE Sum.=   .94 Ceil. m=   .00 Putol:   .62
 Nr.: 14  .91 P N2  .00 P HE Sum.=   .91 Ceil. m=   .00 Putol:   .62
 Nr.: 15  .89 P N2  .00 P HE Sum.=   .89 Ceil. m=   .00 Putol:   .61
 Nr.: 16  .87 P N2  .00 P HE Sum.=   .87 Ceil. m=   .00 Putol:   .61

 what now? A

 maximal Ceiling:   .00

 Proposal Haldane 2:1 [m] =    3

 Proposal Hills, B. A.: DEEP STOP [m] =    8

 PDIS for TAU = 10 min:  16.63 [m]

 PDIS for TAU = 20 min:  14.49 [m]

 PDIS for TAU = 30 min:  12.27 [m]


 Input of Ascent Stage Meter & cm (m.cm):

 Ascent Stage:   .00  Ascent Time:  1.700  P insp N2:  .740  P insp He:  .000

 Nr.:  1 1.9202 P N2  .0000 P HE Sum.=  1.9202 Ceil. m=   .00   Patol:   .333
 Nr.:  2 1.9840 P N2  .0000 P HE Sum.=  1.9840 Ceil. m=   .00   Patol:   .641
 Nr.:  3 1.9680 P N2  .0000 P HE Sum.=  1.9680 Ceil. m=   .00   Patol:   .799
 Nr.:  4 1.8877 P N2  .0000 P HE Sum.=  1.8877 Ceil. m=   .00   Patol:   .885
 Nr.:  5 1.7531 P N2  .0000 P HE Sum.=  1.7531 Ceil. m=   .00   Patol:   .921
 Nr.:  6 1.5995 P N2  .0000 P HE Sum.=  1.5995 Ceil. m=   .00   Patol:   .924
 Nr.:  7 1.4418 P N2  .0000 P HE Sum.=  1.4418 Ceil. m=   .00   Patol:   .870
 Nr.:  8 1.2968 P N2  .0000 P HE Sum.=  1.2968 Ceil. m=   .00   Patol:   .799
 Nr.:  9 1.1743 P N2  .0000 P HE Sum.=  1.1743 Ceil. m=   .00   Patol:   .727
 Nr.: 10 1.0898 P N2  .0000 P HE Sum.=  1.0898 Ceil. m=   .00   Patol:   .682
 Nr.: 11 1.0309 P N2  .0000 P HE Sum.=  1.0309 Ceil. m=   .00   Patol:   .654
 Nr.: 12  .9828 P N2  .0000 P HE Sum.=   .9828 Ceil. m=   .00   Patol:   .636
 Nr.: 13  .9438 P N2  .0000 P HE Sum.=   .9438 Ceil. m=   .00   Patol:   .626
 Nr.: 14  .9119 P N2  .0000 P HE Sum.=   .9119 Ceil. m=   .00   Patol:   .621
 Nr.: 15  .8866 P N2  .0000 P HE Sum.=   .8866 Ceil. m=   .00   Patol:   .613
 Nr.: 16  .8664 P N2  .0000 P HE Sum.=   .8664 Ceil. m=   .00   Patol:   .612
```

This output is the calculated N2/He inertgas partial pressure per compartment, i.e. the saturation, and the sum and the ceiling in m resp. the corresponding pressure in fresh water. There will be a different sum value only for mix gas diving. These lot of numbers could be presented graphically via the plot command “P”: pls. cf. the title sheet. The yellow bars are proportional to the absolute values for N2, the blue ones for He. You could check the absolute values in Bar on the left side, the Y-axis. The white bars are the sum per

compartment. The inspiratory pressure is a thin line: green for N2, blue for He, the white line is the pressure sum. The relative position of the compartment bars to the inspiratory value is an indicator, if the compartment is supersaturated (above, already off-gassing) or is still going to get saturated (below: still on-gassing). The ceiling is this little red line segment per compartment. When its value grows bigger than 1, eg. 1.7, you have to make a deco stop at 7 m.

Next little exercise: we go directly back to the surface with “a” then making a surface interval (SI) over night with “e”, say for 8 h, i.e.: input “480” at depth “0”. We check then the compartment values, and to our astonishment, even for making this little NDL dive, there are still some compartments supersaturated, even after 8 h SI:

```
.
.
 Nr.: 12   .8005 P N2   .0000 P HE Sum.=    .8005 Ceil. m=    .00 Putol:    .422
 Nr.: 13   .8086 P N2   .0000 P HE Sum.=    .8086 Ceil. m=    .00 Putol:    .455
 Nr.: 14   .8134 P N2   .0000 P HE Sum.=    .8134 Ceil. m=    .00 Putol:    .487
 Nr.: 15   .8152 P N2   .0000 P HE Sum.=    .8152 Ceil. m=    .00 Putol:    .510
 Nr.: 16   .8149 P N2   .0000 P HE Sum.=    .8149 Ceil. m=    .00 Putol:    .533

(Now you could do the same thing with a SI of, say 12 h and check, for eg. after 3 consecutive
dives at your favourite maledivian house reef ...Then you check with your regular dive table
which thinks, after SI of 6 or 12 or 15 h you are N2-clean ...)
```

NOTA BENE! Remark concerning the bar charts:
by comparing these with deco desktop software which come with your dive computer (Xmp.: the SDM, the Suunto Dive Manager or the SmartTRAK from UWATEC, the ANALYST from COCHRAN etc. …): there you see normally only relative values. Relative means here: relative to an allowed/tolerated supersaturation, because there the Y-axis is in percent. This is not the case in DIVE. As well you do not see the relation of the compartment saturation to the ambient pressure or to the total inspiratory pressure. DIVE helps here as well.

9 Simulation of a deco dive

We are taking the profile data from the chapter “Quickstart”: 42 m, 21 min, Air; then we are ascending slowly to an intermediate deep stop, followed by an ascent and the stages at 9, 6 and 3 m. The information, which compartment is “leading” into the next deco stop is presented, as well for how long via the commands:
"a" -> desired depth, e.g. 6 m (always deeper than the topical ceiling)
"e" -> target depth of the next stop, e.g. 3 m:

```
 Deko Prognose:
 6m Stopp Prognose Dekozeit:  3.00  Komp.#:  4
 3m Stopp Prognose Dekozeit: 12.00  Komp.#:  6
TTS =  15.00

 was jetzt?e

Eingabe der Dekostufe in Metern & cm:(m.cm): 3.
I: 1 TAU N2:   4. TAU He:   2. TAU Summe:   4.00  Dekozeit:   .30
I: 2 TAU N2:   8. TAU He:   3. TAU Summe:   8.00  Dekozeit:   .87
I: 3 TAU N2:  13. TAU He:   5. TAU Summe:  12.50  Dekozeit:  2.73
I: 4 TAU N2:  19. TAU He:   7. TAU Summe:  18.50  Dekozeit:  2.96
I: 5 TAU N2:  27. TAU He:  10. TAU Summe:  27.00  Dekozeit:   .30
I: 6 TAU N2:  38. TAU He:  14. TAU Summe:  38.30  Dekozeit:   .30
I: 7 TAU N2:  54. TAU He:  21. TAU Summe:  54.30  Dekozeit:   .30
I: 8 TAU N2:  77. TAU He:  29. TAU Summe:  77.00  Dekozeit:   .30
I: 9 TAU N2: 109. TAU He:  41. TAU Summe: 109.00  Dekozeit:   .30
I:10 TAU N2: 146. TAU He:  55. TAU Summe: 146.00  Dekozeit: *****
I:11 TAU N2: 187. TAU He:  71. TAU Summe: 187.00  Dekozeit: *****
```

In this case it is the compartment #4, rounded up to 3 min. Are we on the 3 m stage and want to go to the surface: "a" -> 3 m; "e" -> target depth of next stop is 0 (for the surface), then we will see which compartment leads for this stop: it is #6, rounded up to 12 min:

```
 was jetzt?e

Eingabe der Dekostufe in Metern & cm:(m.cm):
I: 1 TAU N2:   4. TAU He:   2. TAU Summe:   4.00  Dekozeit:   .30
I: 2 TAU N2:   8. TAU He:   3. TAU Summe:   8.00  Dekozeit:   .90
I: 3 TAU N2:  13. TAU He:   5. TAU Summe:  12.50  Dekozeit:  4.64
I: 4 TAU N2:  19. TAU He:   7. TAU Summe:  18.50  Dekozeit:  8.00
I: 5 TAU N2:  27. TAU He:  10. TAU Summe:  27.00  Dekozeit: 10.45
I: 6 TAU N2:  38. TAU He:  14. TAU Summe:  38.30  Dekozeit: 11.12
I: 7 TAU N2:  54. TAU He:  21. TAU Summe:  54.30  Dekozeit:  1.78
I: 8 TAU N2:  77. TAU He:  29. TAU Summe:  77.00  Dekozeit:   .30
I: 9 TAU N2: 109. TAU He:  41. TAU Summe: 109.00  Dekozeit:   .30
```

Your dive computers display / dive table reading will be close to a rounded up, next-higher integer value of the corresponding leading compartment. The protocol file will now look like that:

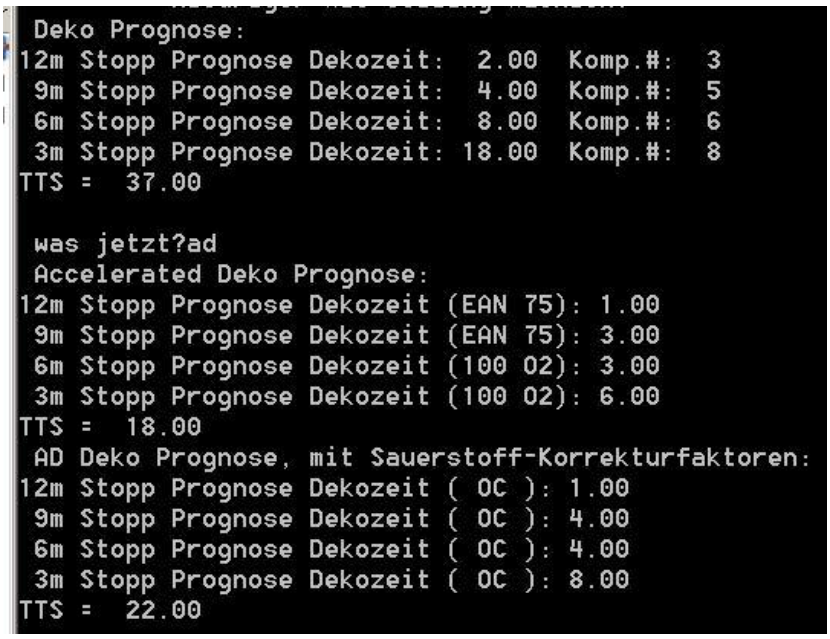
```
*****************************************************************
  Yr: 2010 Mon: 05 D: 19 Hr: 14 Min: 00  Version: 2_9x, 04/2010
Test TG zur JURA
  TIEFE    ZEIT    GES. ZEIT  N     O    HE   CNS   OTU   GAS
 X     .00     .00     .00    .79   .21   .00    0.    0.       .00
 D   42.00   21.00   21.00    .79   .21   .00    9.   24.   2730.00
 A   24.00    1.80   22.80    .79   .21   .00    9.   25.    126.00
 E   24.00    1.00   23.80    .79   .21   .00    9.   26.     85.00
 A   12.00    1.20   25.00    .79   .21   .00    9.   26.    120.00
 E   12.00    1.00   26.00    .79   .21   .00    9.   26.     55.00
 A    6.00     .60   26.60    .79   .21   .00    9.   26.     69.00
 E    6.00    3.00   29.60    .79   .21   .00    9.   26.    120.00
 A    3.00     .30   29.90    .79   .21   .00    9.   26.     36.75
 E    3.00   12.00   41.90    .79   .21   .00    9.   26.    390.00
 A     .00     .30   42.20    .79   .21   .00    9.   26.     39.00
 X     .00     .00     .00    .79   .21   .00    9.   26.       .00

*****************************************************************
```

Starting with the top line we see the actual system time and a stamp from the version in use, followed by the comment (your input at start):
"X": start & end of dive
"D": bottom phase, dive stages
"A": ascent
“E”: desaturation

10 TEC Diving

Simulation of a deco dive with normoxic Trimix and accelerated deco: 50 m for 20 min with Tmx 20/30/50.

Commands / Input:
„m” “.2” “.3” “d“ „50.“ „20“ „a“ resp. „ad“
which yields an automated deco prognosis with EAN50, EAN75 & EAN100 (=EAN98):



You could check the oxygen corrections via “OC” but for short deco stops like that it will not play a decisive role; but you could enter “ASY” and look what an asymmetric desaturation means for the TTS.

Via „V“ you could change your SAC which defaults to 25 L/min: but this is quite ok when diving with a double 12 and two 10 L stage tanks ... During deco stage, 11 – 13 L/min is not bad.

With „M“ you could change at any time the gas mix, unlimited ...so you could dive a so called “optimal mix” which means you stay as close as possible at pO2 of 1.6 Bar during all the deco-stages (implying a lot of mix changes and a lot of tanks you would have to carry around ... :-(. When the pO2 goes above 1.6 Bar the color in the plot (“P”) changes from white to **red.**

11 Deep Stops / way points

The ascent-/desaturation ramp is calculated with 10 m/min (default) as is in the most dive computers/deco softwares. But you could plan more conservatively by making deep / intermediate stops on the way up. You ascend not directly to the ceiling but in the vicinity of the depths of the proposed deep stops with “d” (depth < deep stop) and “1” or “2” or even more minutes to go. You get a guideline for deep stops from various deep stop strategies:

- Method Haldane is the usual pressure reduction 2:1
- Method Hills, after Brian Andrew Hills, from his book „Decompression Sickness“ [102]
- PDIS (Profile Dependant Intermediate Stop) is the UWATEC method, checking the compartment with halftime of TAU = 20 min. This is for Air/EAN: thus we have additive a somewhat slower and a faster compartment on the deco-radar for comparison.
- Is fHe > 0, there will be a ballpark figure as well for the He-Compartments ...
- If there was a change of the matrices via „NC“ or "HC", each with Option 3 and with GF HI / LO uneven 1.0 there will be an output according to the „VGM“- method.

Two specials:

1) a deco time of 0.0 means here that this specific compartment is desaturated or already off-gassed and does not contribute to the deco time.

2) deco times of 99.99 imply that these compartments are under-saturated and can not contribute to deco times: they still are in the process of on-gassing, i.e. they also do actually not contribute to the deco-times.

3) ***** means, this number is just too big for display

Manually inserted deep stop on the way up are often called “way points”. A dive to 51 m & 18 min would look like that with 2 deep stops:

```
 Yr: 2010 Mon: 05 D: 27 Hr: 19 Min: 43  Version: 2_900, 06/2010
Test TG 51 m / 18 min deep stops / Way Points
 TIEFE   ZEIT   GES. ZEIT  N    O   HE  CNS  OTU  GAS
X    .00    .00    .00   .79  .21  .00   0.   0.      .00
D  51.00  18.00  18.00   .79  .21  .00  10.  26.  2745.00
A  30.00   2.10  20.10   .79  .21  .00  11.  28.   162.75
D  30.00   2.00  22.10   .79  .21  .00  11.  29.   200.00 ← deep stop
A  20.00   1.00  23.10   .79  .21  .00  11.  29.   102.50
D  20.00   2.00  25.10   .79  .21  .00  12.  30.   150.00 ← deep stop
A  15.00    .50  25.60   .79  .21  .00  12.  30.    57.50
D  15.00   2.00  27.60   .79  .21  .00  12.  30.   125.00
A   9.00    .60  28.20   .79  .21  .00  12.  30.    78.00
E   9.00   2.00  30.20   .79  .21  .00  12.  30.    95.00
A   6.00    .30  30.50   .79  .21  .00  12.  30.    41.25
E   6.00   6.00  36.50   .79  .21  .00  12.  30.   240.00
A   3.00    .30  36.80   .79  .21  .00  12.  30.    43.50
E   3.00  17.00  53.80   .79  .21  .00  12.  30.   552.50
A    .00    .30  54.10   .79  .21  .00  12.  30.    45.75
X    .00    .00    .00   .79  .21  .00  12.  30.      .00
```

In comparison of DIVE with the Bühlmann ZH-86 table and the DECO2000 table we have:

Stops:	30 m	20 m	15 m	12 m	9 m	6 m	3 m	TTS
ZH-86					4’	5’	13’	27’
Deco 2000				2’	4’	7’	14’	32’
DIVE / way points	2‘	2’	2’	- -	2’	6’	17’	36’
DIVE / „B“				2’	3’	7’	17‘’	34’
DIVE / Deco 2000			1‘	2‘	3‘	9‘	15‘	35‘

TTS is the time-to-surface in minutes: the sum of all deco stops plus the coming-home-ramp with 10 m / min. The standard deco prognosis in relation to the actual valid set of coefficients will be displayed with every ascent (“A”). Other simulation of deco-scenarios are going with: "S", "PMRC", "ASY", "OC" or "AD".

For a deco with pure oxygen we put in “AD” f = 0.98 from 6 m on. According to the U.S. Navy correction factors these deco times have to be increased a little bit. By increasing them even more, DIVE automatically adds the so-called “AIR BREAKS” (prolongation of the deco stop with a normoxic mix).

Let’s have a quick glance at the so-called “run times”, that is our PROTOCOL.TXT which is automatically generated by DIVE, if it finds at start-up the directory C:\DIVE\PROT. The protocols of all subsequent dives are just concatenated, each single dive being marked with:

```
 TIEFE   ZEIT   GES. ZEIT  N    O   HE  CNS  OTU  GAS
X    .00    .00    .00   .79  .21  .00   0.   0.      .00
```

You could delete or copy PROTOCOL.TXT at any time or you could edit it and put your own statements in: Start -> Execute -> NOTEPAD

12 Deco Prognosis

If your diving depth is > 2 m and you ascend with “a” without specifying the ascent depth you will get automatically a deco prognosis from scratch if your NDL is expired. The basis for this calculation is the topical matrix you have loaded (default = ZH-L 16C). Now you could work on your own ascent strategy by „S“ or „PMRC“, „ASY“ or as well „OC“ to check the qualitative or only quantitative changes in the TTS.

NOTA BENE: none of the tools from the tool box will change the calculated compartment values. But all “A”, “E” or “D” input does and as well the Buehlmann correction (“B” factors like: calculational depth = input depth * 1.03 +1), unless you clear everything via “CLR” or shut down and re-start DIVE again.

13 Simulation of a Rebreather (SCR) dive

You could as well simulate dives with a semi-closed rebreather (SCR) like the DRAEGER DOLPHIN or the like. You just have to factor in the reduced oxygen contents in the breathing bag via “M”. As a ballpark you could use for e.g. the “80%” rule. I.e.: your premix maybe an EAN40; 40 * 0,8 = 32: so inside your breathing bag is approx. an EAN32, valid for moderate strenous dives. If you have a CCR, you could use DIVE as well: just change “M” at every stage so that the oxygen partial pressure reflects your setting of the lower or higher set-point of your CCR-equipment.

14 “O” = Time-to-Flight and Desaturation

TTF = „time-to-flight“ is the time until you are allowed to enter a standard civilian airplane with a pressurized cabin; the de-saturation time is the time to more or less a complete desaturation with inertgas against the prevailing ambient air pressure. You know that here we are dealing with exponentials: so a complete desaturation will take place at infinity, which btw is a little bit too long for a dive vacation. Thus we take an arbitrary, but nonetheless very, very small limit: this limit is approx. half of the average daily variation in ambient air pressure, i.e. 20 mbar. To calculate the TTF we use the accepted value of ca. 0.58 bar for the air pressure inside civilian air planes at intercontinental flights:

```
 was jetzt?o
I: 1  Entsaettigungszeit:     5.73 min.       Zeit bis Flug:     .00  --
I: 2  Entsaettigungszeit:    15.49 min.       Zeit bis Flug:     .00  --
I: 3  Entsaettigungszeit:    29.95 min.       Zeit bis Flug:     .00  --
I: 4  Entsaettigungszeit:    49.41 min.       Zeit bis Flug:     .00  --
I: 5  Entsaettigungszeit:    74.86 min.       Zeit bis Flug:    7.33 min.
I: 6  Entsaettigungszeit:   105.91 min.       Zeit bis Flug:   19.70 min.
I: 7  Entsaettigungszeit:     2.45   h.       Zeit bis Flug:   35.56 min.
I: 8  Entsaettigungszeit:     3.37   h.       Zeit bis Flug:   56.15 min.
I: 9  Entsaettigungszeit:     4.60   h.       Zeit bis Flug:   80.43 min.
I:10  Entsaettigungszeit:     5.94   h.       Zeit bis Flug:  107.64 min.
I:11  Entsaettigungszeit:     7.35   h.       Zeit bis Flug:    2.24   h.
I:12  Entsaettigungszeit:     9.02   h.       Zeit bis Flug:    2.81   h.
I:13  Entsaettigungszeit:    10.98   h.       Zeit bis Flug:    3.50   h.
I:14  Entsaettigungszeit:    13.26   h.       Zeit bis Flug:    4.47   h.
I:15  Entsaettigungszeit:    15.82   h.       Zeit bis Flug:    5.48   h.
I:16  Entsaettigungszeit:    18.62   h.       Zeit bis Flug:    7.18   h.

 was jetzt?Entsaettigung und Zeit bis flug fuer den TMX 20/30/50: 50 m/20'
```

Now the desaturation time at the display on your dive computer would be just 19 h or even more, which is the rounded maximum of compartment # 16; the TTF would be announced as 8 to 12 h .... both depending on which limits your equipment uses. But apart from this, the recommendations from UHMS will remain totally unaffected, i.e.: to wait 24 h!

15 Surface Mode / Dive Planer / rolling NDL Table

Normally all dive computers will feature a planning modus and / or a rolling NDL-table during SI. You simulate the SI either with “d”, “0.0” “dive time = SI in min” or “e” “0.0” “deco stop = SI in min”, that is either a dive or a deco stop a depth = 0.0. Then with “T” you get the standard NDL table in the usual 3m spacing. Now could change as well the mix (“M” if your repetitive dive is with EAN) or “L” if you drive to Lake Tahoe ... During SI the %CNS dose is reduced via the accepted 90 min halftime. Anyway you could get more than 100 during aggressive O2-diving: DIVE switches then internally from NOAA to the USN %CNS doses!

16 respiratory Quotient

Workload or nutrition can be factored in a little bit into DIVE via the respiratory quotient “RQ” with 0.5 < Rq < 1.5. With low Rq by average workload or fat rich nutrition the ceiling goes down where as with high workload resp. carbohydrate rich nutrition it goes up. Default for Rq = 1.0 (Buehlmann / Hahn), others may put that to a different value; i.e.: USN Rq = 0.9, or Heinz R. Schreiner wants Rq = 0.8.

17 Mountain Lake Diving

The default ambient air pressure at sea level is 1 ATM, approx. 1000 mbar. You change that via “L” for eg. a dive in a mountain lake where you have reduced ambient pressure up there. The rule-of-thumb is to reduce the 1.0 with 0.1 for every 1000 m of altitude. Xmp.: your favourite lake is at approx. 1.500 m altitude, so you key in: “L” “0.85”. Then have a look at the reduced NDL via “T”. This yields without adaption!

18 Adaption / start-up ramp

When you now control via „Z“ or „P“ the compartment values, you will see that the reduced NDLs are valid for the saturation from sea-level. If you want to simulate the adaption to the new height or the so-called “start-up ramp” you just key in the approved deco-stop at dive depth 0.0. Now you could check again the compartment values and you will see, that slowly, slowly the inertgas saturation will fall to the new equilibrium values at altitude.

19 Error / Out-of-Range

A basic difference between DIVE and a real dive computer is the performance during a procedural error. If you ascend by far and by long to fast, if your prognosed stops start too deep and are too long or if you don’t obey a deco stop for a certain time-intervall. In dive computers there is normally a threshold for 0.8 Bar for 2 to 3 min: if you exceed the product of the both, the box blacks out, either with a fall back to gauge modus or with a lot of beeping or just an error message like: “ERROR” or “Out of Range” for 12 – 24 – 48 h. This normally takes place, when the pure mathematics would go nuts by division through zero or a logarithm from a negative value. DIVE blocks these situations with simple outputs like:

„Ascent first“ resp. „Stage deeper“ or the like ...

20 Pre Breathing

If you breathe pure oxygen prior to dive you start to desaturate your body from inertgas. The reflection of this you will find in the calculated compartment values. Xmp.: simulation of a 15 min pre-breathing at the surface:

„m“ = 1.0 then „d“ with depth = 0.0 and time = 15

Via “P” you could control if the desaturation takes place really or you check via “N” and the depth of your planned next dive, if the NDL has become bigger. This btw. is the method used by astronauts prior to EVA (extra-vehicular activity).

21 Isobaric Counterdiffusion (ICD)

Analogous to pre-breathing or the start-up ramp you could simulate ICD. Xmp.: you offer your diver a normoxic Heliox at the surface with „m“ „ .2“ „ .8“. If you make now an SI you could watch via “P” how the Helium-Wave of supersaturation makes it’s way from the left to right on the display, i.e. from the fast to the slow compartments as a function of time.

22 Hints for the Tool Box

With:

„S“

(like „Simulation“) we will have 2 different ascent strategies / deco scenarios with:

- Security Surcharges
- Conservativism Factors

A typical security surcharge is just an extra “markup” in percent to a calculated stoptime: you could do it by yourself mentally as soon as your computer displays a stop time or if you come up with the result from a table. These surcharges are just rounded up to the next positive integer and are in the range of:

15, 20 and 25 %

The conservativism factors a la method of COCHRAN, SUUNTO or MARES are simply additional compartment saturations, also in the percent range. Normally you could key these ones in by yourself into your dive computer at topics like: fitness factors, obesity, age, etc ... These additional compartment saturations result in related additional deco stops resp. shortened NDL.

With:

„PMRC“

(„Proportional M-Value Reduction Concept“) you simulate a deco scenario according to the PMRC from the DSL, the Diving Safety Laboratory from DAN / UWATEC from 2001. It is simply a reduction of the M-values (which you got to know in our specialty courses ...). Proportional means here in relation basically to the lambda value, that is the inverse of the compartment halftime, i.e. in plain language: the shorter the halftime the bigger the reduction.

“ASY” “RL” “OC”:
Haldane once had the brilliant idea in ca. 1907 that the desaturation is hindered or even totally blocked once you have bubbles. But part of his ideas, as well the idea with deep stops was put to oblivion during the course of history. During the 80’s these ideas surfaced again in the shape of MB- (=micro bubbles) algorithms in the then UWATEC dive computers, as well Buehlmann formulated his concepts of the Right-to-Left shunt. These ideas are basically implemented through the commands „ASY“ („asymmetrical” de-saturation) and “RL”. „OC“ is another asymmetric desaturation taking into account the oxygen correction factors evaluated by the NMRI (Naval Medical Research Institute). Oxygen works as a vasoconstrictor (diminishes the diameter of blood vessels) and makes a bradycardia (slows down the heart rate): both make the desaturation slower and less inefficient in comparison to the calculated one, dependant only on the oxygen partial pressure. If the corrections are too long, then DIVE will add automatically the so-called “AIR BREAKS” to the TTS.

23 Expert Mode: the Coefficient Matrix

The coefficient matrices are the array-like combinations of the following parameters: # of compartment, halftime TAU, A-coefficient, B-coefficient, GF HI, GF LO. Except the gradient factors: all these are common to the so-called “Post Haldane” models based on blood-perfusion. There is abundant literature (or you join our specialty courses) on how to transform the A-, B-coefficients into a M0/Delta M style-algorithm. Via

„NC“

for the N2/Nitrogen coeffcients or „HC" for the Helium coefficients you could change these values through one of these following options: 3 for ”NC” or 2 for “HC”:

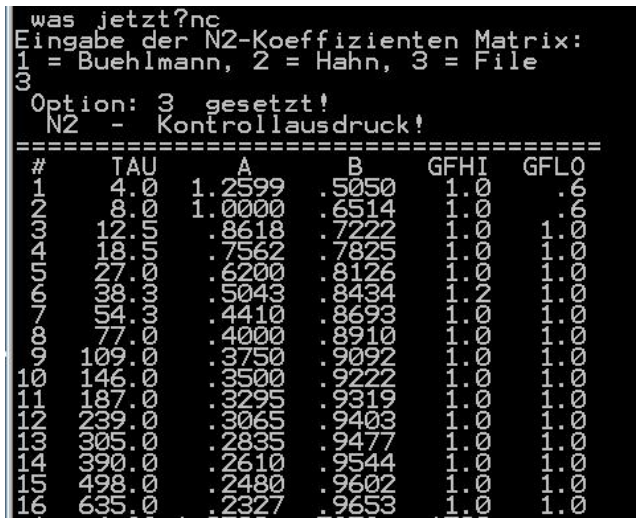
1: the original Buehlmann coefficients (default)
2: Hahn coefficients, all about the same to get the DECO2000 table
3: input of the matrices: N2COEFF.TXT (for nitrogen) resp. HECOEFF.TXT (for Helium).
These have to have a definite lay-out and a definite location, otherwise it won't work, really! DIVE expects them at

C:\DIVE\PROT\N2COEFF.TXT
C:\DIVE\PROT\HECOEFF.TXT

The lay-out is exactly like that, including the blanks! Xmp.: for N2:

```
#    TAU        A       B       HI    LO
01     4.0   1.2599   .5050    0.9   0.8
02     8.0   1.0000   .6514    0.9   0.8
03    12.5    .8618   .7222    0.9   0.8
04    18.5    .7562   .7825    0.9   0.8
05    27.0    .6200   .8126    0.9   0.8
06    38.3    .5043   .8434    0.9   0.8
07    54.3    .4410   .8693    0.9   0.8
08    77.0    .4000   .8910    0.9   0.8
09   109.0    .3750   .9092    0.9   0.8
10   146.0    .3500   .9222    0.9   0.8
11   187.0    .3295   .9319    0.9   0.8
12   239.0    .3065   .9403    0.9   0.8
13   305.0    .2835   .9477    0.9   0.8
14   390.0    .2610   .9544    0.9   0.8
15   498.0    .2480   .9602    0.9   0.8
16   635.0    .2327   .9653    0.9   0.8
```

You could change these very easily with any ASCII Editor (eg.: NOTEPAD; via: Start -> Execute -> Notepad). After input via option „3" there follows immediately an output for control: if there are any deviations from your ideas, just repeat the above steps...:



Hint: it is relatively pointless to use Hahn coefficients and then PMRC or the like: your stop times will just grow to infinity... As well there are well-set boundaries to the original Buehlmann coefficients, because these are linked directly to the halftime. But it could make sense that you change a relatively liberal set like the COCHRAN or U.S.Navy and then afterwards a PMRC (ok, ok, ok: this is why it's called the "Expert Mode" ☺)

As well if you change *just only one* GF HI of GF LO in the matrix against 1.0, DIVE automatically invokes the "VGM", the "Variable Gradient Method" and changes the output for deco prognosis accordingly:

```
 Deko Prognose:
12m Stopp Prognose Dekozeit:   1.00  Komp.#:  2
 9m Stopp Prognose Dekozeit:   3.00  Komp.#:  3
 6m Stopp Prognose Dekozeit:   6.00  Komp.#:  4
 3m Stopp Prognose Dekozeit:  15.00  Komp.#:  6
TTS =  30.00
 GF FLAG: V   Deko Prognose nach VGM:
18m Stopp Prognose VGM Deko:   1.00  Komp..: 2 GFHI: 1.00 GFLO:  .60 GF =  .60
15m Stopp Prognose VGM Deko:   1.00  Komp..: 2 GFHI: 1.00 GFLO:  .60 GF =  .67
12m Stopp Prognose VGM Deko:   2.00  Komp..: 2 GFHI: 1.00 GFLO:  .60 GF =  .73
 9m Stopp Prognose VGM Deko:   2.00  Komp..: 2 GFHI: 1.00 GFLO:  .60 GF =  .80
 6m Stopp Prognose VGM Deko:   5.00  Komp..: 4 GFHI: 1.00 GFLO: 1.00 GF = 1.00
 3m Stopp Prognose VGM Deko:  12.00  Komp..: 5 GFHI: 1.00 GFLO: 1.00 GF = 1.00
```

In contrast to the regular deco prognosis you see as well for the leading compartment the GF HI/LO boundaries and the actual working gradient factor for the runtime (GF =).

24 „LS“ = the „last stop“ Option!

Here we change the depth of the last stop before the drop-out to the surface. Normally this is at 3 m: but there are various situations where it makes sense to have a couple of feet of water more overhead:

- Mountain Lake Diving: the last stop could be around 2 m due to the reduced ambient pressure
- Current, swell, boat traffic: well, sometimes 6 or even more is as well safer ...
- Tec / Mix gas dives: with a lot of Helium in the mix the last stop is around 4 – 6 m
- Accelerated Deco / 100 % O2: the most efficient desaturation takes place with pure oxygen at around 6 m
- USN Table, Rev. 6 / 2008: the last stop is solely at 20 feet!
- Heliox tables for commercial diving: last stop normally at 9 m

25 „GF“ = the regular gradient factors

With the input of the two gradient factors GF HI and GF LO via command “GF” you force DIVE to a more conservative calculation without having the trouble of the file-manipulation as per “NC”, “HC”. But these 2 factors work then for the complete host of the 16 compartments. (Thus, once again, in contrast to the VGM, pls. cf. below: here you have the gradient factors per each compartment separately!) Xmp.: dive to 30 m, 30 min with GF HI = 0.9, GF LO = 0.5:

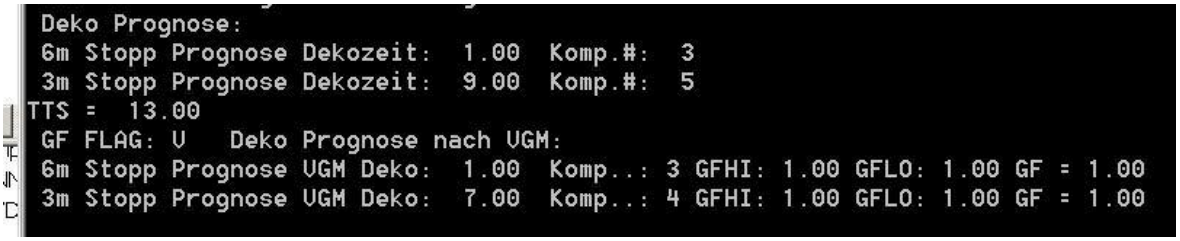
```
 Deko Prognose:
 6m Stopp Prognose Dekozeit:   1.00  Komp.#:  3
 3m Stopp Prognose Dekozeit:   9.00  Komp.#:  5
TTS =  13.00
 Deko Prognose mit Gradientenfaktoren:  GFHI=    .90 GFLO=    .50
12m Stopp Prognose Dekozeit:   1.00  GF =    .50  Komp.#:  2
 9m Stopp Prognose Dekozeit:   3.00  GF =    .60  Komp.#:  3
 6m Stopp Prognose Dekozeit:   6.00  GF =    .70  Komp.#:  4
 3m Stopp Prognose Dekozeit:  14.00  GF =    .80  Komp.#:  6
TTS =  27.00
```

The GF LO starts here with 0.5 and forces the deeper stops at 12 & 9 m instead of 6. The stop at 6 m is prolonged due to the actual working GF of 0.7. At 3 m the working GF is now 0.8 and makes the stop even longer. As you surface you have reached the intended GF of 0.9. Besides the stop times you see in the prognosis the actual working GF, so you could check if the ramp from GF LO to GF Hi is what you want it to be, and the leading compartment which may change from standard deco to GF-deco.

26 VGM: the Variable Gradient Method

With the VGM you could change the GF HI and GF LO per compartment according to your subjective / physiologic status. Thus you could put the factors not only < 1 (the standard GF method, pls. cf. above) but as well > 1! In this manner you provoke via the aggressive algorithm a shortening of the deco times.

Follows a little illustration of this with the dive from above (30 m, 30 min). Off all the 80 parameters for N2 in the matrix we changed only 1 of them; i.e. the GF Hi from 1.0 to 1.1 for the compartment #5:



This output shows that the stop time for the last stop dropped from 9 to 7 min and that the leading compartment moved from #5 to #4.

The regular VGM simulators/tools have normally only 3 compartment ranges (fast, medium, slow) to change the parameters. Here with DIVE you could do it in detail for every compartment, and, as well separately for N2 and He.

27 „AR“ = ascent rate

from ca. 1 up to 100 (for apnea/no-limit breathhold diving) m/min

28 „AD“ = accelerated deco

With the MOD close to a max pO2 of 1.6 Bar there is an automated calculation of accelerated decompression with the following suite of EAN gases: 50, 75 and pure oxygen, aka EAN100. Internally the EAN100 is calculated with 98 because in this mean ‘ole world nothing is a 100 %!

29 „MX“ = Matrix of the weighted Coefficients

For mix gas calculations all the coefficients of the matrix (A-, B-, TAU-) have to be weighted according to their partial pressure in the corresponding compartment; the accepted paradigm looks like that (Xmp.: for the A-coefficient):

$$a_{Mixgas} = (a_{N2} * p_{CompartmentN2} + a_{He} * p_{CompartmentHe}) / (p_{CompartmentN2} + p_{CompartmentHe})$$

Only the compartment-# as such stays: everything else is set in relation to the sum of the inertgas partialpressures. Here it is very easy to loose track: therefore you could check with “MX” the topical values valid only for the runtime.

30 “PDCS” = Probability of Decompression Sickness

Here we have a couple of different methods of assessing the probability of decompression sickness P(DCS).

Method I: model from: Southerland, David Graham: PHD Thesis, 1992, p. 78 & p. 9
Method II: PME Model, we adapted it to 6 compartments for TEC Diving with Helium
Method III: adapted risc function from “Statistically Based Decompression Tables”; Part VI, p.5 & 55
Method IV: NEDU Report from 12/2004: TR 04-41, p.8 & p. 11, without any adaption from our side

Method V: NEDU TR 03-2009, under development ...

NOTA BENE! The parameters of all of the above P(DCS) algorithms are being fitted via huge data bases of 1000's of documented dry or wet dives. The interpretation of the P(DCS) figures is only meaningful when the simulated dive is close to the data base of these calibration dives!

31 „CLR" = „CLEAR" , Table of the „default" Values

```
 NZWO = 0.79
OZWEI = 0.21
HELIUM = 0.0
AMV = 25.0
RQ = 1.0
PSTART = 1.0
BKORR = 'N'
FIRSTOP = 3.0
LASTSTOP = 3.0
GFFLAG = 'N'
GFHI = 1.0
GFLO = 1.0
AR = 10.
GFHIA = 1.0
GFLOA = 1.0
HEGFHIA = 1.0
HEGFLOA = 1.0
PGEWEBE = NZWO * PSTART
HEPGEW = HELIUM * PSTART
PGEWSUM = PGEWEBE + HEPGEW
LAMBDA = LOG(2.) / TAU
HELAMBDA = LOG(2.) / HETAU
PUTOL = 0.58
CEILING = 0.0
```

The above is an excerpt from the FORTRAN source code. You put all the variables into their defaults via „CLR". Similar as „EX" and restart of DIVE.

32 A hint for expert-novices and TEC-Divers:

„Don't fall prey to the computer narcosis!"

With the many simulations & features from DIVE you will get a gut feeling, that with a reasonable training (i.e.: a good instructor), a little bit of experience and drill (i.e. a couple of good dives) and with common sense and a reasonable dive plan you are able to question, if you need a failure-prone Hi-Tech dive computer or an overpriced expensive desktop deco-software ...

Next hint: don't follow the display of your dive computers blindly! All these products, may it be the hard- or a software, may have bugs! Check the output with common sense, try to put it together with your experience and the dive computers of your buddies. If you dive mix gas, try to compare your diveplans with well-known, accepted, tried and tested mixgas tables (U.S. Navy, DCIEM, COMEX etc.) and try to make it more conservative with your personal experience.

33 Literature (mostly german …)

- The manual for the PADI / SSI „DIVE TABLES & DIVE COMPUTERS" Specialty from the Tauchsportcenter Esslingen, http://www.tauchturm.com

- Dekompression: manual for our deco workshop, shortened online version for free:

http://www.divetable.de/skripte/Deko_Manual.pdf

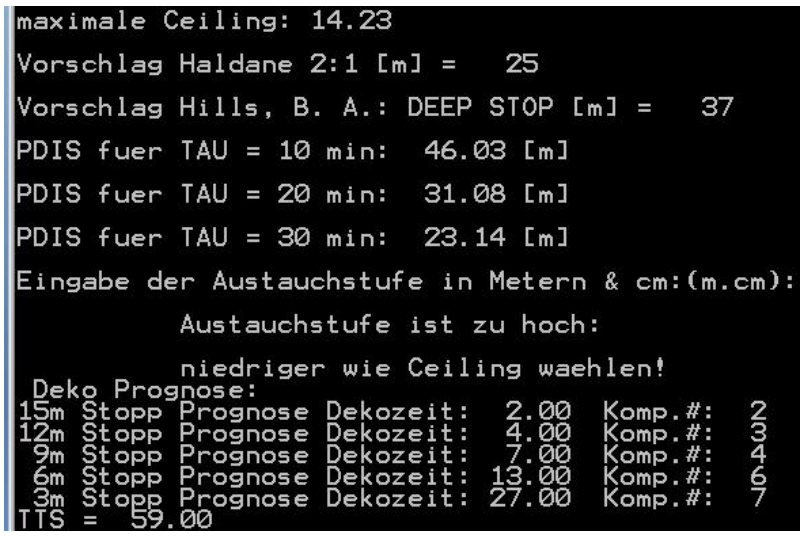
- Theory of decompression calculations: http://www.divetable.de/theorie.htm
- More books: http://www.divetable.de/books/index.htm

34 Alphabetical Index (-> pls. cf. next version ...)

35 Attachment: QA for DIVE V 2_900; June 2010

Comparison of a few profiles with standard tools and standard tables as a QA measure; the # in the square brackets is the reference # from: http://www.divetable.de/books/index.htm

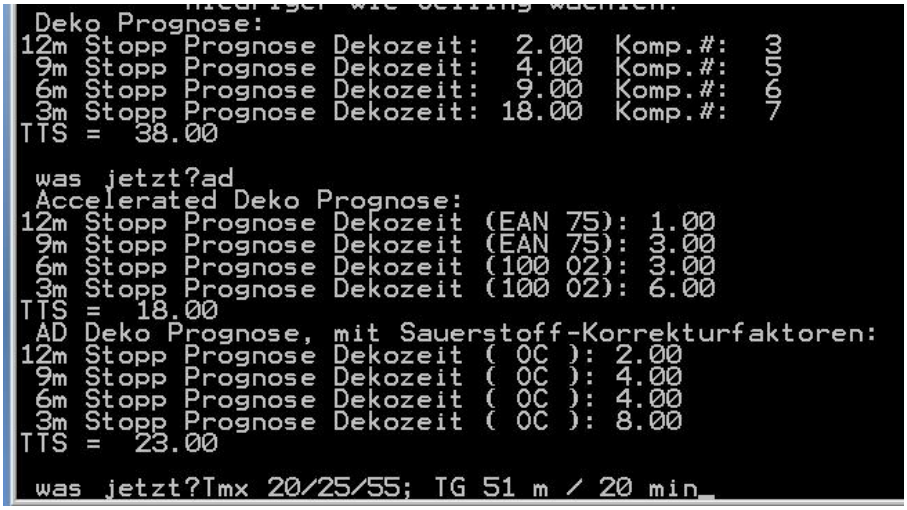
1) Buehlmann / ZH-86, [65], p. 228: Air 60 m / 21 min:
   15 m / 3‘
   12 m / 4‘
   9 m / 6‘
   6 m / 11‘
   3 m / 28‘



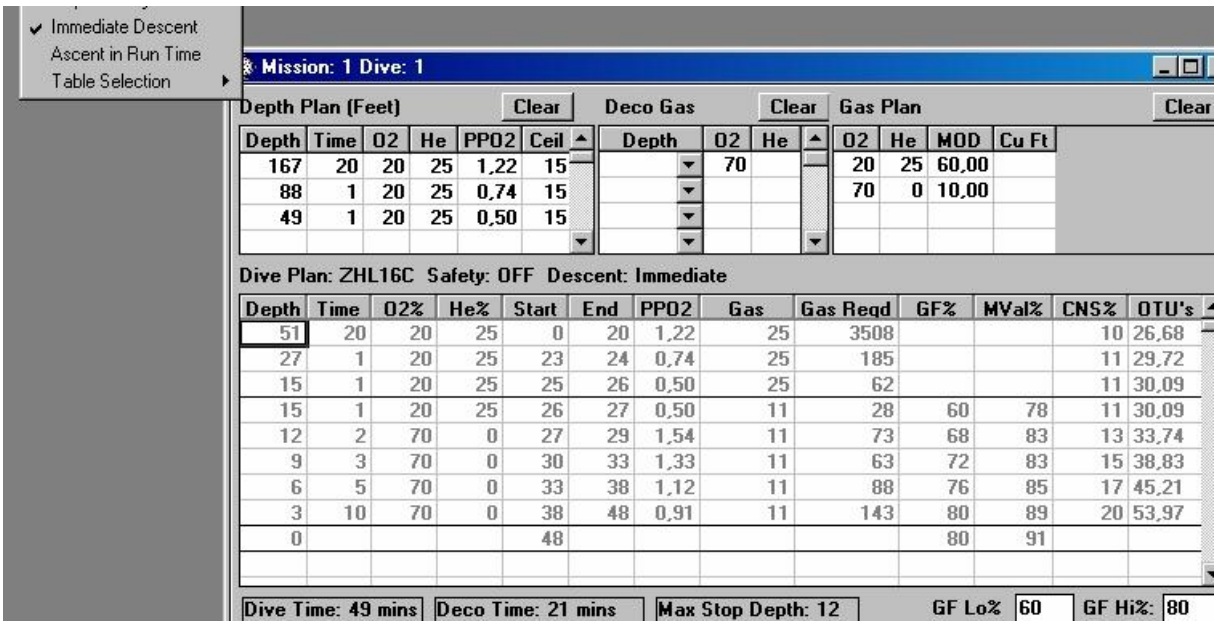
2) <u>IANTD [46], p. 265: Tmx20/25/55, 51 m / 20 min:</u>
   27 m / 1‘ Back Gas
   15 m / 1‘ Back Gas
   12 m / 3‘ EAN70
   9 m / 3‘ EAN70
   6 m / 2‘ EAN70
   3 m / 15‘; EAN70, 21 % CNS

   DIVE 2_90 w.o. deep stops, with back gas: 2, 4, 9, 18

   With accelerated deco („AD“): 1, 3, 3, 6



<u>GUE DP 2.0.40:</u>
Back Gas: 4, 7, 17
EAN70: 2, 4, 8
With EAN75 & EAN98: 2, 3, 7
With deep stops & EAN70 & GF 80 / 60:



With deep stops & EAN 70 as above: 1, 1, 3, 5, 10

DIVE with deep stops & GF:

```
 Deko Prognose:
 9m Stopp Prognose Dekozeit:   3.00  Komp.#:   4
 6m Stopp Prognose Dekozeit:   4.00  Komp.#:   5
 3m Stopp Prognose Dekozeit:   8.00  Komp.#:   7
TTS =  16.00
 Deko Prognose mit Gradientenfaktoren:  GFHI=    .80 GFLO=    .60
15m Stopp Prognose Dekozeit:   2.00  GF =    .60  Komp.#:   3
12m Stopp Prognose Dekozeit:   3.00  GF =    .64  Komp.#:   4
 9m Stopp Prognose Dekozeit:   3.00  GF =    .68  Komp.#:   5
 6m Stopp Prognose Dekozeit:   5.00  GF =    .72  Komp.#:   6
 3m Stopp Prognose Dekozeit:  10.00  GF =    .76  Komp.#:   7
TTS =  24.00

 was jetzt?Tmx 20/25/55 51m/20', deep stop 27 & 15 / BackGas, dann EAN70
```

Back Gas & AD & GF:

```
 Deko Prognose:
12m Stopp Prognose Dekozeit:   2.00  Komp.#:   3
 9m Stopp Prognose Dekozeit:   4.00  Komp.#:   5
 6m Stopp Prognose Dekozeit:   9.00  Komp.#:   6
 3m Stopp Prognose Dekozeit:  18.00  Komp.#:   7
TTS =  38.00
 Deko Prognose mit Gradientenfaktoren:  GFHI=    .80 GFLO=    .60
18m Stopp Prognose Dekozeit:   2.00  GF =    .60  Komp.#:   3
15m Stopp Prognose Dekozeit:   2.00  GF =    .63  Komp.#:   4
12m Stopp Prognose Dekozeit:   4.00  GF =    .67  Komp.#:   4
 9m Stopp Prognose Dekozeit:   7.00  GF =    .70  Komp.#:   5
 6m Stopp Prognose Dekozeit:  13.00  GF =    .73  Komp.#:   7
 3m Stopp Prognose Dekozeit:  31.00  GF =    .77  Komp.#:   8
TTS =  64.00

 was jetzt?ad
 Accelerated Deko Prognose:
12m Stopp Prognose Dekozeit (EAN 75): 1.00
 9m Stopp Prognose Dekozeit (EAN 75): 3.00
 6m Stopp Prognose Dekozeit (100 02): 3.00
 3m Stopp Prognose Dekozeit (100 02): 6.00
TTS =  18.00
 AD Deko Prognose, mit Sauerstoff-Korrekturfaktoren:
12m Stopp Prognose Dekozeit ( OC ): 2.00
 9m Stopp Prognose Dekozeit ( OC ): 4.00
 6m Stopp Prognose Dekozeit ( OC ): 4.00
 3m Stopp Prognose Dekozeit ( OC ): 8.00
TTS =  23.00
 Accelerated Deco Prognose mit  Gradientenfaktoren:  GFHI=    .80 GFLO=    .60
18m Stopp Prognose Dekozeit (EAN 50): 1.00  GF =    .60  Komp.#:   3
15m Stopp Prognose Dekozeit (EAN 75): 1.00  GF =    .63  Komp.#:   3
12m Stopp Prognose Dekozeit (EAN 75): 3.00  GF =    .67  Komp.#:   4
 9m Stopp Prognose Dekozeit (EAN 75): 4.00  GF =    .70  Komp.#:   5
 6m Stopp Prognose Dekozeit (100 02): 4.00  GF =    .73  Komp.#:   6
 3m Stopp Prognose Dekozeit (100 02): 9.00  GF =    .77  Komp.#:   7
TTS =  27.00
```