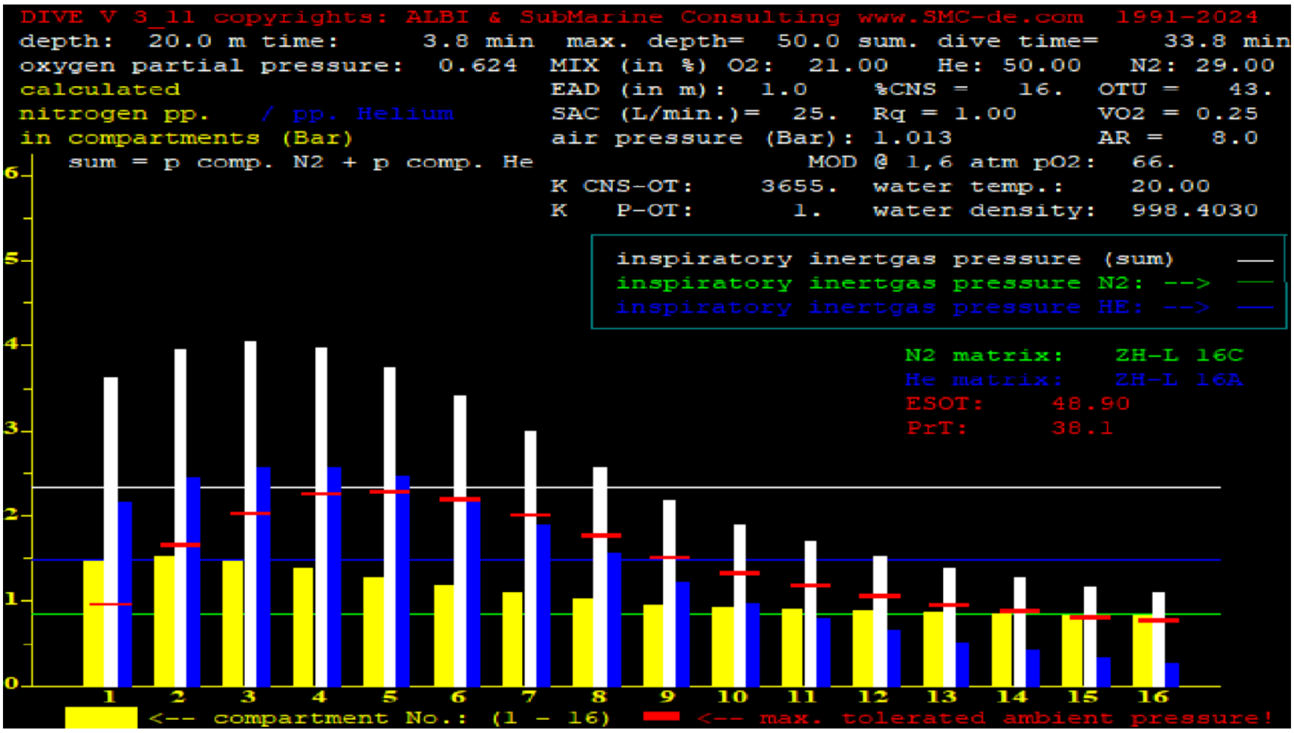
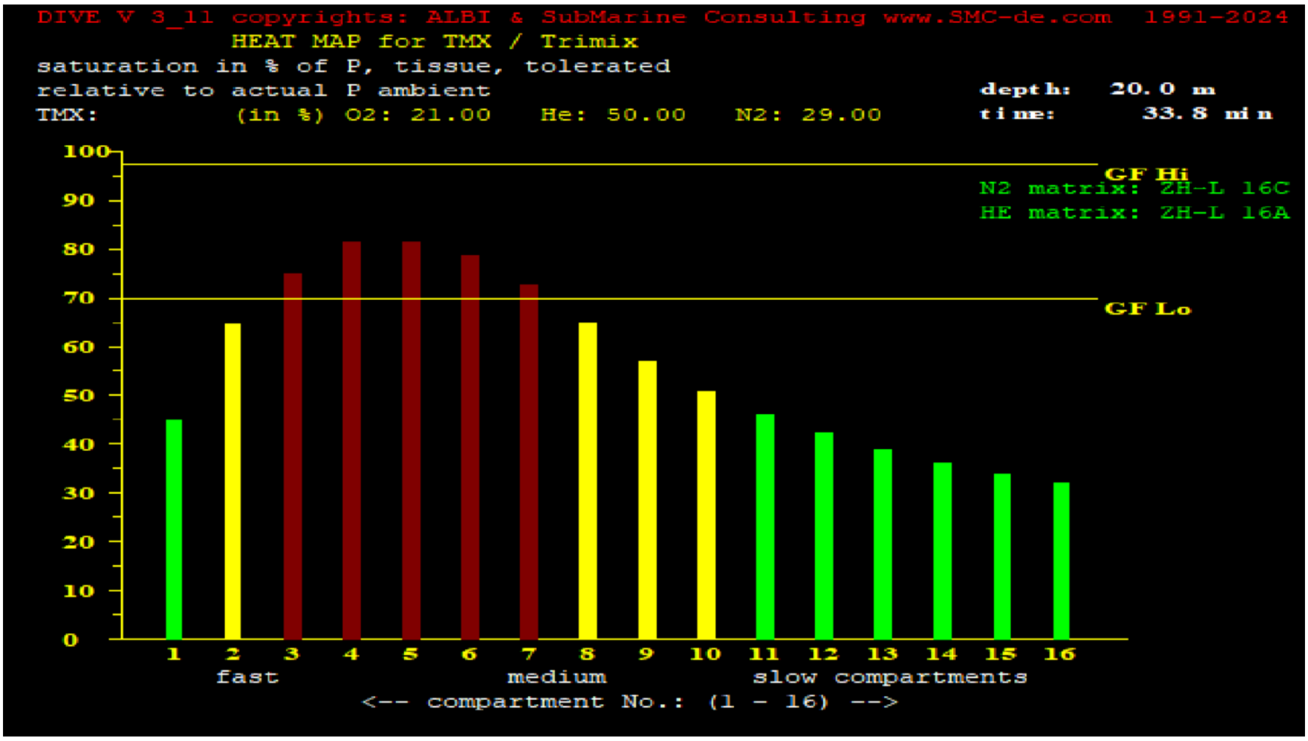
DIVE Version 3_11
Software Manual



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2024
depth:  20.0 m time:      3.8 min  max. depth=  50.0 sum. dive time=    33.8 min
oxygen partial pressure:  0.624  MIX (in %) O2:  21.00   He: 50.00   N2: 29.00
calculated                       EAD (in m):  1.0     %CNS =   16.  OTU =   43.
nitrogen pp.   / pp. Helium      SAC (L/min.)=  25.   Rq = 1.00     VO2 = 0.25
in compartments (Bar)            air pressure (Bar): 1.013          AR =   8.0
   sum = p comp. N2 + p comp. He              MOD @ 1,6 atm pO2:  66.
                                 K CNS-OT:    3655.  water temp.:     20.00
                                 K   P-OT:       1.  water density:  998.4030
```



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2024
          HEAT MAP for TMX / Trimix
saturation in % of P, tissue, tolerated
relative to actual P ambient                              depth:   20.0 m
TMX:          (in %) O2: 21.00   He: 50.00   N2: 29.00    time:    33.8 min
```

THE

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WWW.SMC-DE.COM

Manual and documentation for the desktop deco software:
„DIVE“ Version 3_11 (from 11/2021), Version: 04 / 2025

Table of Contents:

1 Quickstart

Simulation of a deco dive:

after download and un-packing of the DIVE ZIP-archive:

- Double-click in the Explorer on "D3_xx.exe" (xx = # of minor release) or:

Opening of a DOS-Box and running the program via:

- Start → Execute → "CMD" (cmd.exe), alternative:
- Windows Key + „R“ → „CMD“

then: change to the appropriate directory with: „CD“
calling DIVE: "D3_xx.exe"

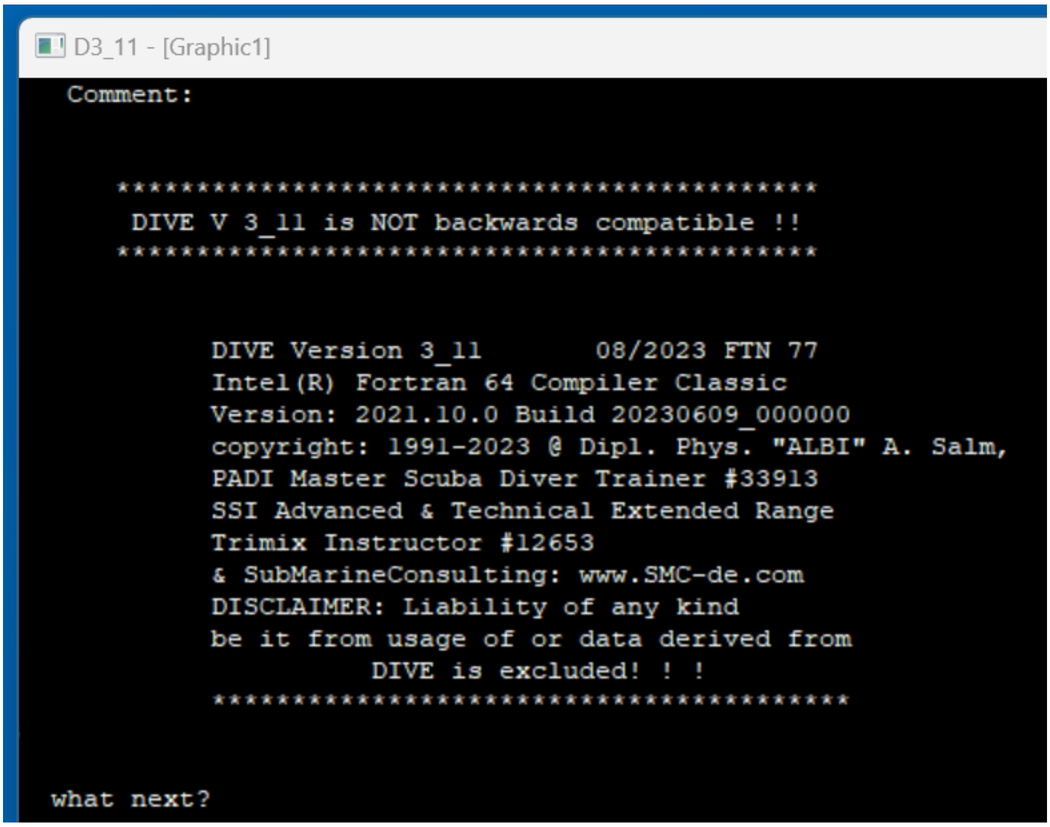
We simulate a deco dive on air to 42 m, 25 min bottom time; the software asks repeatedly: „what next?“ and we just key-in the various inputs:

what next?

these inputs are, in sequential order:

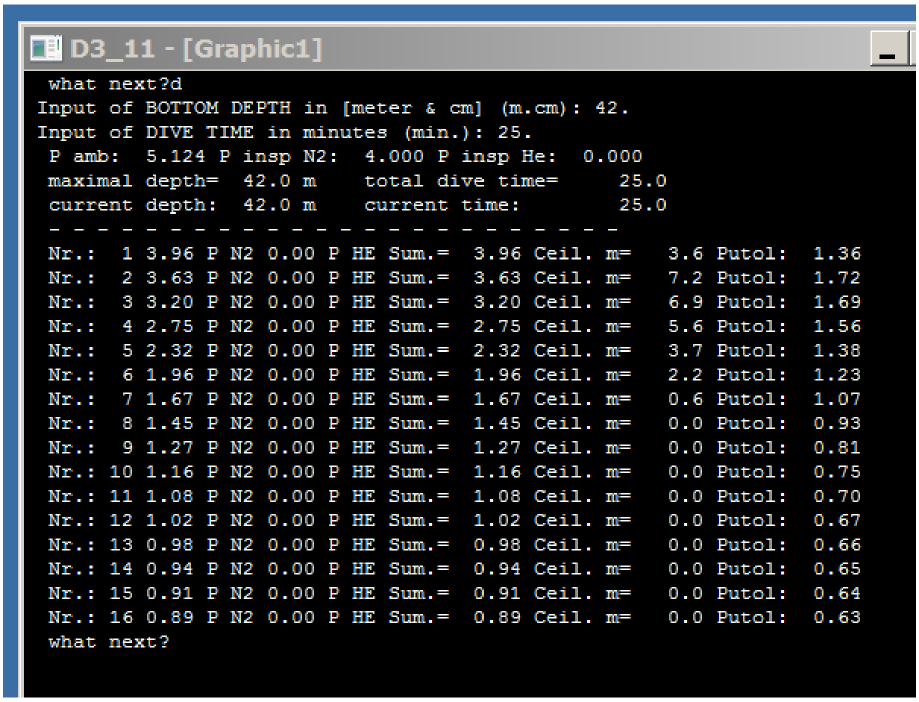
"**d**" (for acess to the „dive“ - dialogue)
"**42.**" (for the bottom depth)
"**25.**" (for the bottom time)

and we recieve the following output:



```
 Comment:


    *******************************************
     DIVE V 3_11 is NOT backwards compatible !!
    *******************************************


          DIVE Version 3_11       08/2023 FTN 77
          Intel(R) Fortran 64 Compiler Classic
          Version: 2021.10.0 Build 20230609_000000
          copyright: 1991-2023 @ Dipl. Phys. "ALBI" A. Salm,
          PADI Master Scuba Diver Trainer #33913
          SSI Advanced & Technical Extended Range
          Trimix Instructor #12653
          & SubMarineConsulting: www.SMC-de.com
          DISCLAIMER: Liability of any kind
          be it from usage of or data derived from
                    DIVE is excluded! ! !
          ****************************************


what next?
```

1-1: BANNER / welcome message



```
 what next?d
Input of BOTTOM DEPTH in [meter & cm] (m.cm): 42.
Input of DIVE TIME in minutes (min.): 25.
 P amb:  5.124 P insp N2:  4.000 P insp He:  0.000
 maximal depth=  42.0 m    total dive time=     25.0
 current depth:  42.0 m    current time:        25.0
 - - - - - - - - - - - - - - - - - - - - - - - -
 Nr.:  1 3.96 P N2 0.00 P HE Sum.=  3.96 Ceil. m=   3.6 Putol:  1.36
 Nr.:  2 3.63 P N2 0.00 P HE Sum.=  3.63 Ceil. m=   7.2 Putol:  1.72
 Nr.:  3 3.20 P N2 0.00 P HE Sum.=  3.20 Ceil. m=   6.9 Putol:  1.69
 Nr.:  4 2.75 P N2 0.00 P HE Sum.=  2.75 Ceil. m=   5.6 Putol:  1.56
 Nr.:  5 2.32 P N2 0.00 P HE Sum.=  2.32 Ceil. m=   3.7 Putol:  1.38
 Nr.:  6 1.96 P N2 0.00 P HE Sum.=  1.96 Ceil. m=   2.2 Putol:  1.23
 Nr.:  7 1.67 P N2 0.00 P HE Sum.=  1.67 Ceil. m=   0.6 Putol:  1.07
 Nr.:  8 1.45 P N2 0.00 P HE Sum.=  1.45 Ceil. m=   0.0 Putol:  0.93
 Nr.:  9 1.27 P N2 0.00 P HE Sum.=  1.27 Ceil. m=   0.0 Putol:  0.81
 Nr.: 10 1.16 P N2 0.00 P HE Sum.=  1.16 Ceil. m=   0.0 Putol:  0.75
 Nr.: 11 1.08 P N2 0.00 P HE Sum.=  1.08 Ceil. m=   0.0 Putol:  0.70
 Nr.: 12 1.02 P N2 0.00 P HE Sum.=  1.02 Ceil. m=   0.0 Putol:  0.67
 Nr.: 13 0.98 P N2 0.00 P HE Sum.=  0.98 Ceil. m=   0.0 Putol:  0.66
 Nr.: 14 0.94 P N2 0.00 P HE Sum.=  0.94 Ceil. m=   0.0 Putol:  0.65
 Nr.: 15 0.91 P N2 0.00 P HE Sum.=  0.91 Ceil. m=   0.0 Putol:  0.64
 Nr.: 16 0.89 P N2 0.00 P HE Sum.=  0.89 Ceil. m=   0.0 Putol:  0.63
 what next?
```

1-2: compartments 1 --> 16 and the ceiling

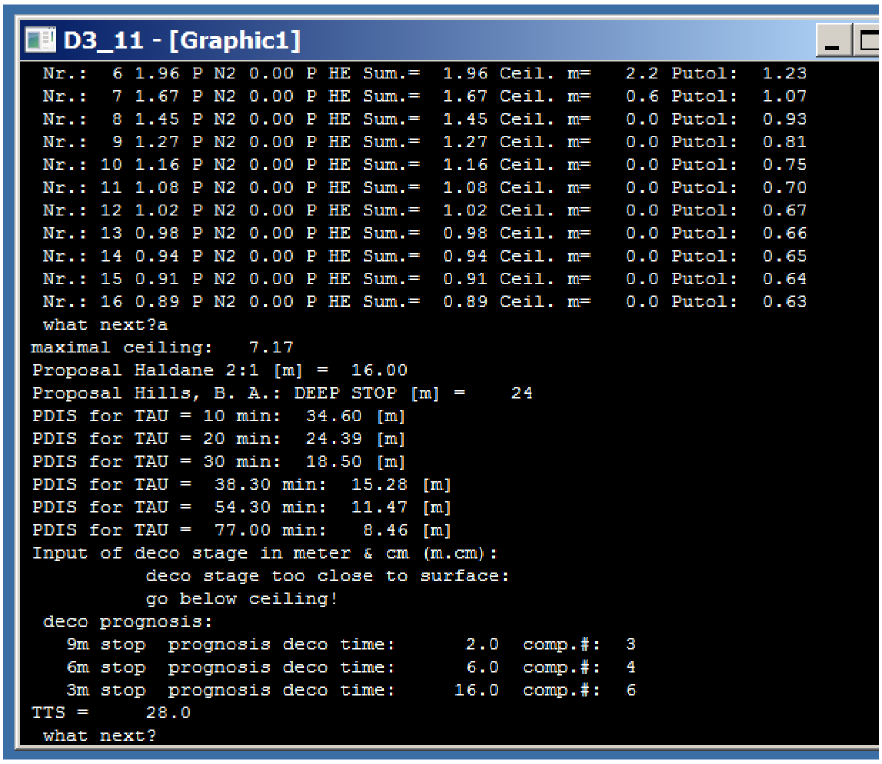
after this:

"a" (for access to the „ascent“ - dialogue)

„Input of deco step in meter & cm:_ “

" "

(void, this input is equivalent to a depth of = 0.0) and we recieve immediately the suggestions for various deep stops and the complete deco prognosis, very much like the output from a standard dive table:



```
  Nr.:  6 1.96 P N2 0.00 P HE Sum.= 1.96 Ceil. m=  2.2 Putol: 1.23
  Nr.:  7 1.67 P N2 0.00 P HE Sum.= 1.67 Ceil. m=  0.6 Putol: 1.07
  Nr.:  8 1.45 P N2 0.00 P HE Sum.= 1.45 Ceil. m=  0.0 Putol: 0.93
  Nr.:  9 1.27 P N2 0.00 P HE Sum.= 1.27 Ceil. m=  0.0 Putol: 0.81
  Nr.: 10 1.16 P N2 0.00 P HE Sum.= 1.16 Ceil. m=  0.0 Putol: 0.75
  Nr.: 11 1.08 P N2 0.00 P HE Sum.= 1.08 Ceil. m=  0.0 Putol: 0.70
  Nr.: 12 1.02 P N2 0.00 P HE Sum.= 1.02 Ceil. m=  0.0 Putol: 0.67
  Nr.: 13 0.98 P N2 0.00 P HE Sum.= 0.98 Ceil. m=  0.0 Putol: 0.66
  Nr.: 14 0.94 P N2 0.00 P HE Sum.= 0.94 Ceil. m=  0.0 Putol: 0.65
  Nr.: 15 0.91 P N2 0.00 P HE Sum.= 0.91 Ceil. m=  0.0 Putol: 0.64
  Nr.: 16 0.89 P N2 0.00 P HE Sum.= 0.89 Ceil. m=  0.0 Putol: 0.63
  what next?a
 maximal ceiling:   7.17
 Proposal Haldane 2:1 [m] =  16.00
 Proposal Hills, B. A.: DEEP STOP [m] =    24
 PDIS for TAU = 10 min:  34.60 [m]
 PDIS for TAU = 20 min:  24.39 [m]
 PDIS for TAU = 30 min:  18.50 [m]
 PDIS for TAU =  38.30 min:  15.28 [m]
 PDIS for TAU =  54.30 min:  11.47 [m]
 PDIS for TAU =  77.00 min:   8.46 [m]
 Input of deco stage in meter & cm (m.cm):
           deco stage too close to surface:
           go below ceiling!
  deco prognosis:
    9m stop  prognosis deco time:     2.0  comp.#:  3
    6m stop  prognosis deco time:     6.0  comp.#:  4
    3m stop  prognosis deco time:    16.0  comp.#:  6
 TTS =      28.0
  what next?
```

1-3: suggestions for various deep stops and the deco prognosis

For each stage (3, 6, 9 m, …) we see the deco time (hang-time) and the compartment #, which is responsible for this time (the „**leading compartment**“) and the **TTS** (time-to-surface, i.e.: sum of all hang-times plus ascent time (i.e.: = bottom depth / ascent rate)).

This little software is muttering a bit („deco stage too close to surface“) because the input of 0.0 m is to high for the allowed ceiling of ca. 7 m, but this is just fyi, without any dire consequences. That’s it !!!

****

Just one remark here, at the start of this manual: the default algorithm used is the so called: „ZH-L 16“ from our late colleague Albert Alois Bühlmann. ZH stands for Zuerich, his hometown in Switzerland, where he worked at the „Universitätsspital“ and set-up the famous decompression chamber for the deep heliox trials, „L“ is for linear, a simple linear equation (straight line) for the calculation of the allowed / tolerated ambient pressures, and 16 is the number of the a-/b- pairs, not the number of parallel perfused compartments: there have been other models, like the „ZH-L $_{12}$“ which sports as well 16 compartments, but only 12 sets of the coefficients. If you have a good working command of the german language, you may check there:

[4] Dekompression - Dekompressionskrankheit, A. A. Bühlmann, Springer, 1983, ISBN 3-540-12514-0

[5] Tauchmedizin (Barotrauma, Gasembolie, Dekompression, Dekompressionskrankheit) A. A. Bühlmann, Springer, 1993, ISBN 3-540-55581-1

[65] "Tauchmedizin.", Albert A. Bühlmann, Ernst B. Völlm (Mitarbeiter), P. Nussberger; 5. Auflage in 2002, Springer, ISBN 3-540-42979-4

This default method could be changed easily (see: „nc“ or the chapter „Expert Mode“), not needed now & here for a quick start!

2 Table of pictures

3 list of tables

C:\DIVE\Manuals\DIVE_Manuals\DIVE V3\3_11\DOXV3_0.docx,
# of pages: 110, up to date: 14.03.2025 18:22

4 What is really new?

In this blue info box you will see the most recent changes / updates to the latest DIVE release and the manual:

→ what is now new in the D3_11 on the BETA test site???

The D3_11 has an english user-interface stacked on top of the service-engine of D3_10; i.e.: D3_11 is feature-identical to the „old“ german D3_10 from 03.09.2021. The following is a short-list of features, that were in D3_04 not available:

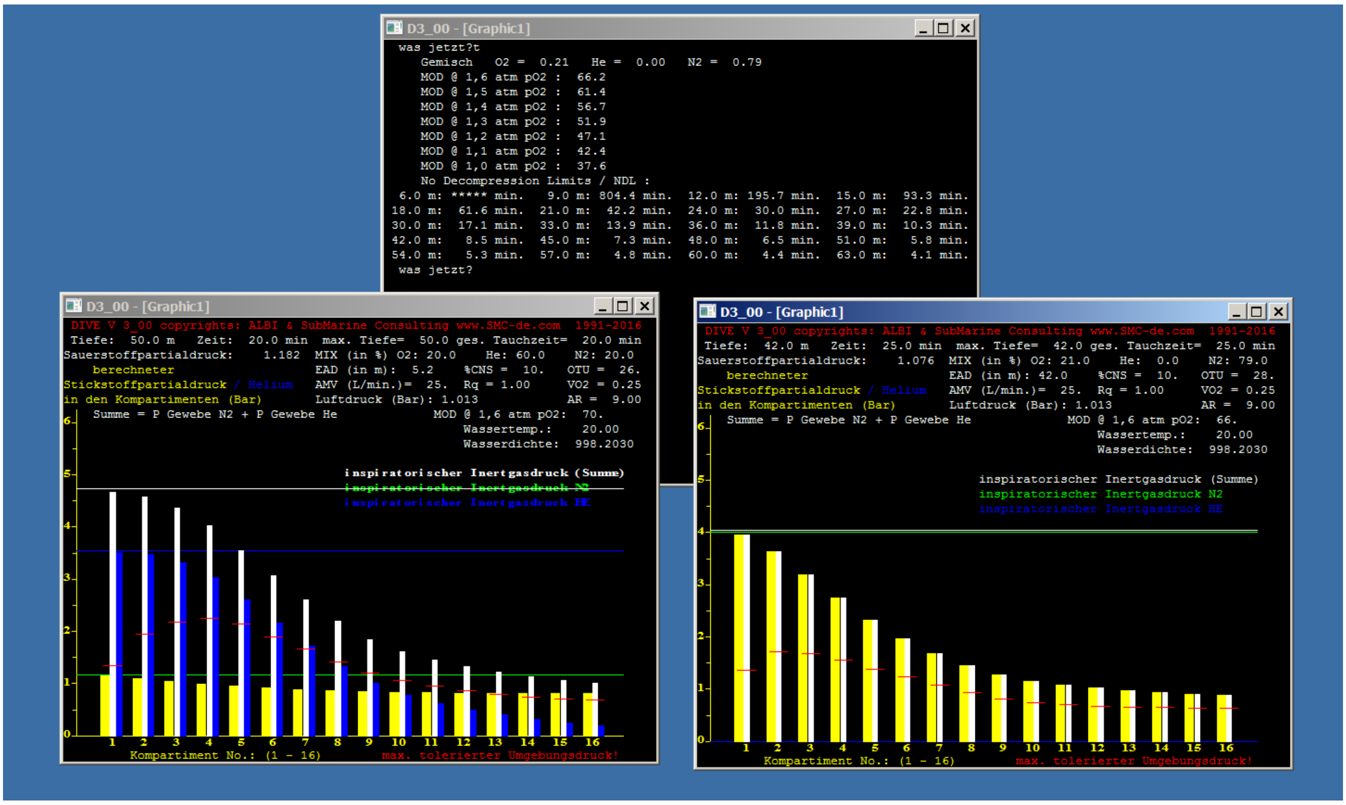
→ the K-values from Ran Arieli / IDF for CNS-& P-OT with
→ „Z“ and „P“, as well the according:
→ „recovery function“ for recovery from ox-tox during SI
→ these values are passed to the: PROTOCOL.TXT.
→ along with the „PrT“ value for deco stress
→ and planning sub-routine for the „k“-values
➔ the new ESOT index as replacement for the UPTD / OTU
→ MT92 / COMEX, NORMAM-15 & USN SAT procedures as simple rule-of-three
→ along a little tool for gasmanagement
→ a lot of references to the RESEARCHGATE via the DOI (digital object identifier) to our latest research papers / conference presentations; the complete list in time-wise order there:

➔ https://www.researchgate.net/profile/Albi-Salm-2

→„extended“ quality assurance: i.e. comparisons with already calculated run-times from A.A.Bühlmann and the MT92, the french pro-table
→ „tbm“ for planning of caisson or tunnel work with a tunnel boring machine; since this is basically oriented along german legislation, the DruckLV BRDrs. 327/13, there is not much english output
➔ „bsc“ for „Buehlmann Shunt Correction“
→ basically, since D3_06, DIVE is no longer backwards compatible, i.e.: the ascii interfaces have been changed: the run-times files & the compartment saturation have a slightly different file-format & all the P(DCS) calculations are no longer comparable to the older DIVE versions due to an adaption of some error-margins. However, the deco prognosis did not change at all (well, well: maybe, in some cases, in the 3.rd or 4th. digit …)
→ „ds“ for deco stress displays Hempleman’s PrT criterion for the the topical and all previous dive segments along with the DCIEM „I“ deco stress index
➔ the coefficients for N_2 and He for the TONAWANDA IIa model from the DCAP manual Version 6.6 (2002)
➔ „cnvr“: a little tool to convert the usual pressure units
➔ and yes: well, a couple of the screen shots stem from older versions …

5 … windowing!

DIVE is able to run in multiple instances in parallel, thus you could compare different deco-scenarios directly:



```
 was jetzt?t
    Gemisch   O2 =  0.21   He =  0.00   N2 =  0.79
    MOD @ 1,6 atm pO2 :  66.2
    MOD @ 1,5 atm pO2 :  61.4
    MOD @ 1,4 atm pO2 :  56.7
    MOD @ 1,3 atm pO2 :  51.9
    MOD @ 1,2 atm pO2 :  47.1
    MOD @ 1,1 atm pO2 :  42.4
    MOD @ 1,0 atm pO2 :  37.6
    No Decompression Limits / NDL :
  6.0 m: ***** min.   9.0 m: 804.4 min.  12.0 m: 195.7 min.  15.0 m:  93.3 min.
 18.0 m:  61.6 min.  21.0 m:  42.2 min.  24.0 m:  30.0 min.  27.0 m:  22.8 min.
 30.0 m:  17.1 min.  33.0 m:  13.9 min.  36.0 m:  11.8 min.  39.0 m:  10.3 min.
 42.0 m:   8.5 min.  45.0 m:   7.3 min.  48.0 m:   6.5 min.  51.0 m:   5.8 min.
 54.0 m:   5.3 min.  57.0 m:   4.8 min.  60.0 m:   4.4 min.  63.0 m:   4.1 min.
 was jetzt?
```

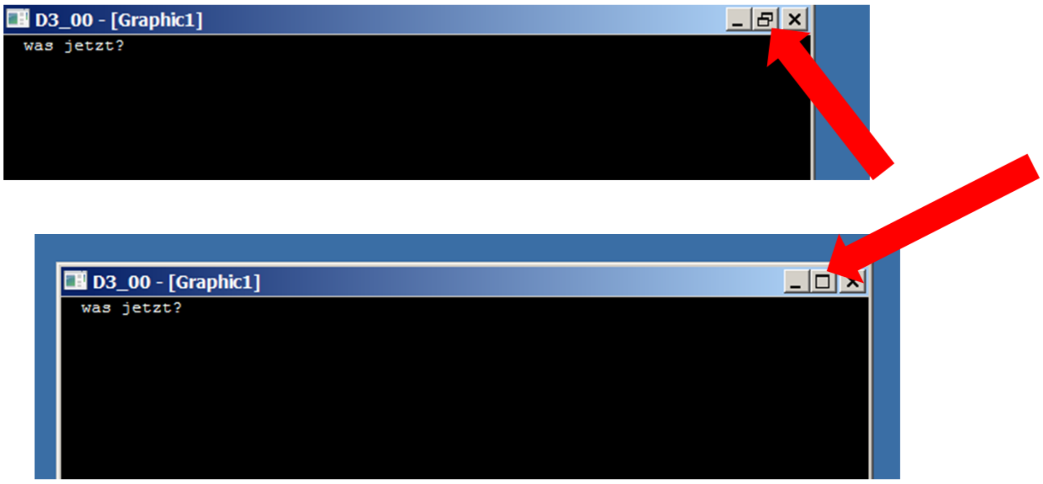
```
 DIVE V 3_00 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2016
 Tiefe:  50.0 m   Zeit:  20.0 min  max. Tiefe=  50.0 ges. Tauchzeit=  20.0 min
Sauerstoffpartialdruck:    1.182  MIX (in %) O2: 20.0    He: 60.0    N2: 20.0
    berechneter                   EAD (in m):  5.2    %CNS =  10.   OTU =  26.
Stickstoffpartialdruck / Helium   AMV (L/min.)=  25.  Rq = 1.00     VO2 = 0.25
in den Kompartimenten (Bar)       Luftdruck (Bar): 1.013            AR =  9.00
    Summe = P Gewebe N2 + P Gewebe He            MOD @ 1,6 atm pO2:  70.
                                                    Wassertemp.:    20.00
                                                    Wasserdichte:  998.2030

                                          inspiratorischer Inertgasdruck (Summe)
                                          inspiratorischer Inertgasdruck N2
                                          inspiratorischer Inertgasdruck HE
```

```
 DIVE V 3_00 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2016
 Tiefe:  42.0 m   Zeit:  25.0 min  max. Tiefe=  42.0 ges. Tauchzeit=  25.0 min
Sauerstoffpartialdruck:    1.076  MIX (in %) O2: 21.0    He:  0.0    N2: 79.0
    berechneter                   EAD (in m): 42.0    %CNS =  10.   OTU =  28.
Stickstoffpartialdruck / Helium   AMV (L/min.)=  25.  Rq = 1.00     VO2 = 0.25
in den Kompartimenten (Bar)       Luftdruck (Bar): 1.013            AR =  9.00
    Summe = P Gewebe N2 + P Gewebe He            MOD @ 1,6 atm pO2:  66.
                                                    Wassertemp.:    20.00
                                                    Wasserdichte:  998.2030

                                          inspiratorischer Inertgasdruck (Summe)
                                          inspiratorischer Inertgasdruck N2
                                          inspiratorischer Inertgasdruck HE
```

5-1: windowing ....

The very first instance running uses the protocol file exclusively (if you have the appropriate directory structure, pls. cf. chapter „Set Up“).

Manipulation (moving, size) of the graphical windows is by clicking on the Window-Symbol, pls. cf. the red arrows:



```
 was jetzt?
```

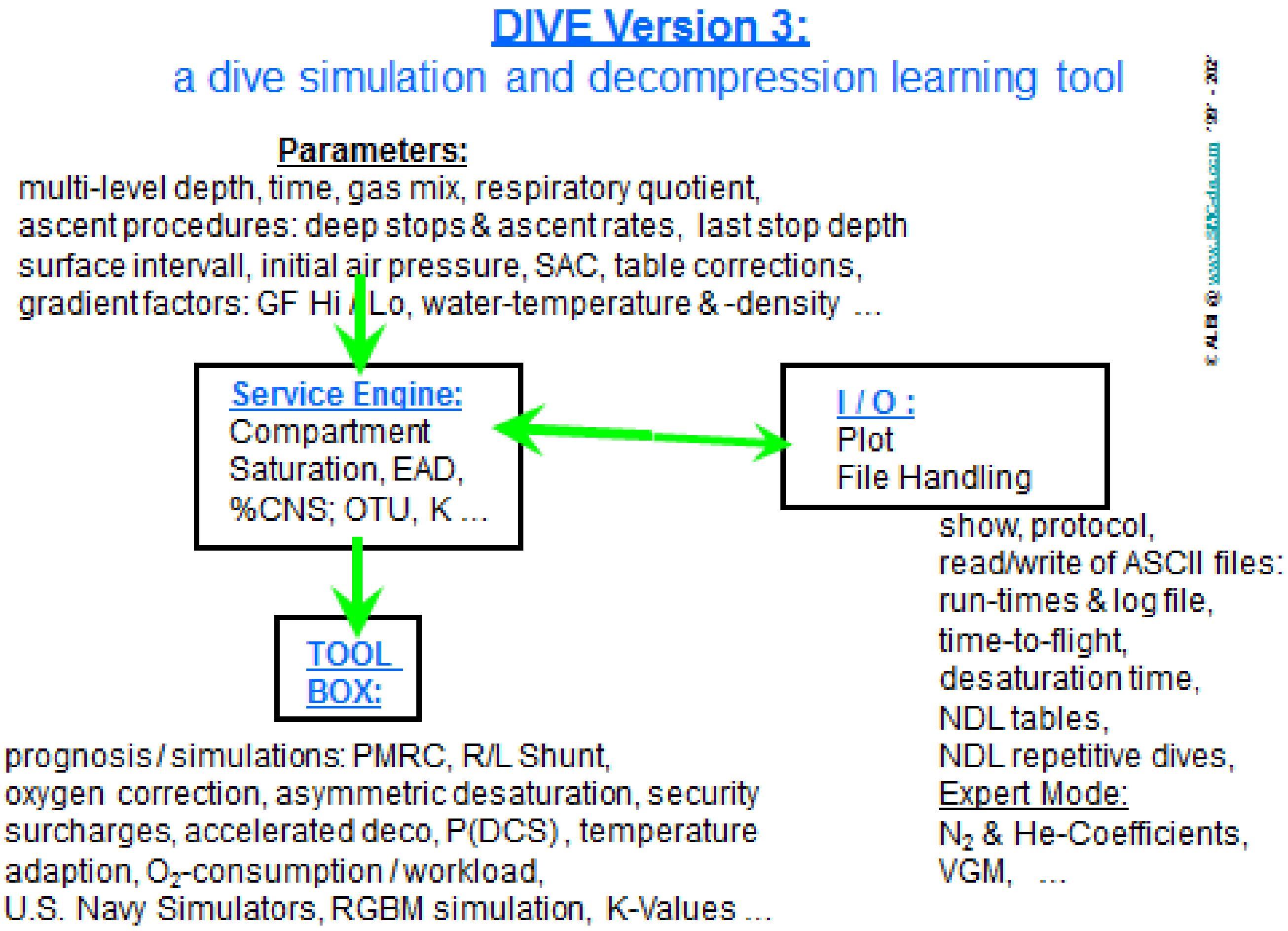
```
 was jetzt?
```

5-2: Window Symbol

If you hit : „Alt“ + „Return“

Or just the „esc“ (escape-button)
you toggle between the 2 modes of the graphical windows: window vs. full-screen.

The basic idea you will see in the architecture overview of „DIVE“:
the input of a couple of standard parameters for a dive drives the „Service Engine“ and the calculation of the inertgas partialpressures within the compartments. Display and storage of the data is done within an „I/O“ Module (Input / Output). These data can be manipulated via a lot of different tools from the „Tool Box“, the original data being kept on-line without any alteration unless you move your little cyber-diver up or down:



DIVE Version 3:
a dive simulation and decompression learning tool

Parameters:
multi-level depth, time, gas mix, respiratory quotient,
ascent procedures: deep stops & ascent rates, last stop depth
surface intervall, initial air pressure, SAC, table corrections,
gradient factors: GF Hi / Lo, water-temperature & -density ...

Service Engine:
Compartment
Saturation, EAD,
%CNS; OTU, K ...

I / O :
Plot
File Handling
show, protocol,
read/write of ASCII files:
run-times & log file,
time-to-flight,
desaturation time,
NDL tables,
NDL repetitive dives,
Expert Mode:
N_2 & He-Coefficients,
VGM, ...

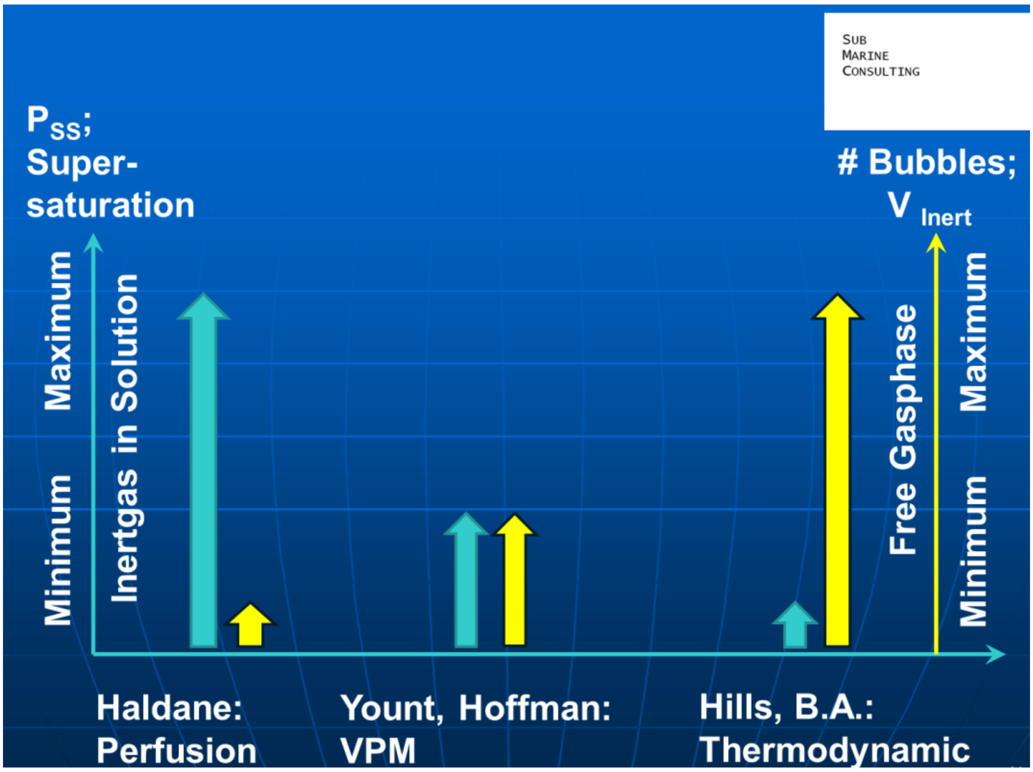
TOOL BOX:
prognosis / simulations: PMRC, R/L Shunt,
oxygen correction, asymmetric desaturation, security
surcharges, accelerated deco, P(DCS), temperature
adaption, O_2-consumption / workload,
U.S. Navy Simulators, RGBM simulation, K-Values ...

5-3: Architecture Overview of DIVE

With this architecture it is relatively simple to embedd new decompression algorithms:
the service engine with its saturation & de-saturation formulas is common to ALL deterministic algorithms, being it a perfusion-model (Haldane, Workman, Schreiner, Buehlmann, Hahn, …) or any bubble-model (VPM, RGBM) or the thermodynamic, like the one from Hills, B.A.

The only difference, speaking from the point of procedures, is nominally only ONE equation (or one subroutine, as you would have it): it is the determination of a ceiling or a safe-ascent-depth (SAD) and how long you are obliged to stay there. It is just that the basic physiology and the basic math for this little subroutine is different. But in the case of Hills, B.A., it may turn out to be an algorithmic nightmare with lots of Bessel-Functions of various orders …

To put this one a little bit more into perspective, let’s have a look at the 2 following charts:



SUB MARINE CONSULTING

P_{SS};
Super-
saturation

Bubbles;
V_{Inert}

Minimum Maximum

Inertgas in Solution

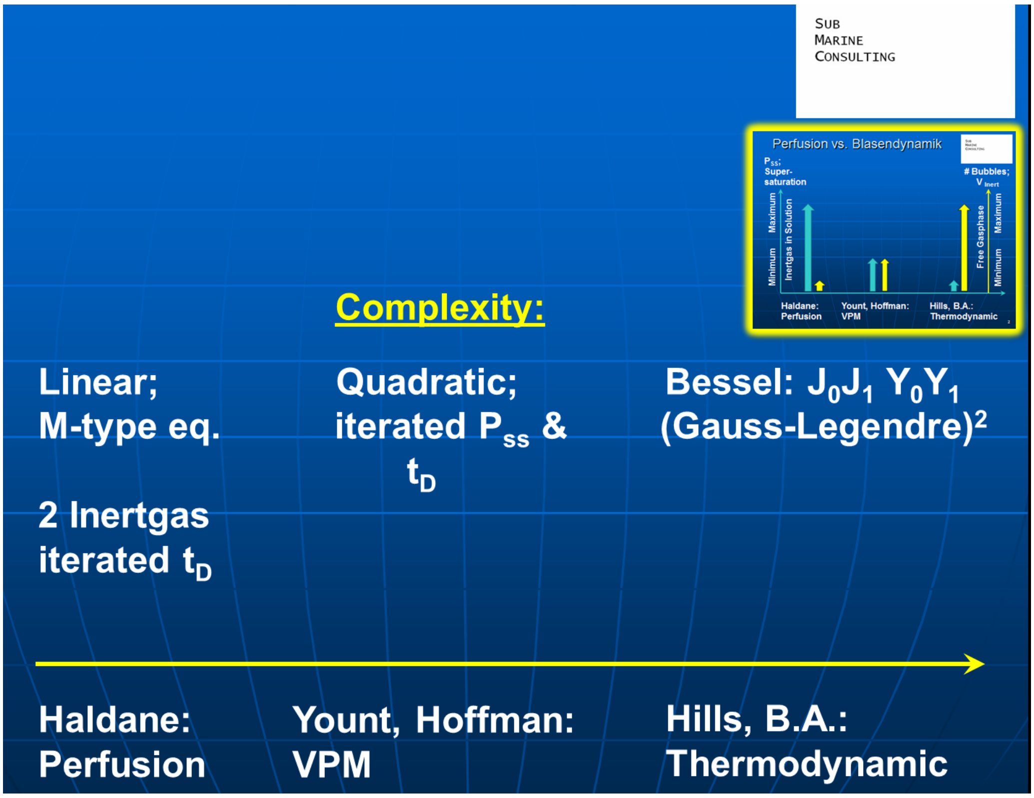
Free Gasphase

Maximum Minimum

Haldane:
Perfusion

Yount, Hoffman:
VPM

Hills, B.A.:
Thermodynamic



SUB MARINE CONSULTING

Perfusion vs. Blasendynamik

Complexity:

Linear;
M-type eq.

2 Inertgas
iterated t_D

Quadratic;
iterated P_{ss} &
t_D

Bessel: $J_0J_1\ Y_0Y_1$
(Gauss-Legendre)^2

Haldane:
Perfusion

Yount, Hoffman:
VPM

Hills, B.A.:
Thermodynamic

5-4: Comparison of various decompression-models

(Source:
AMC, Amsterdam, 03/2018: International Symposion on 21.st Century Decompression Theory;
Dual Phase Decompression Theory and Bubble Dynamics, available at:
https://www.divetable.info/skripte/Bubble_Dynamics_02.pdf)

6 Disclaimer

This software is intended for the PADI Specialties „Dive Computer“ resp. „Dive Tables“, any TEC courses, and, as well, **THE „deco workshop“**. Any warranty or liability, be it through the use of this software or their results is herewith explicitly repudiated.

We would enjoy feedback via e-Mail, be it a bug-report or suggestions for improvement.

7 Set Up

DIVE is „download, Click-&-Run“:

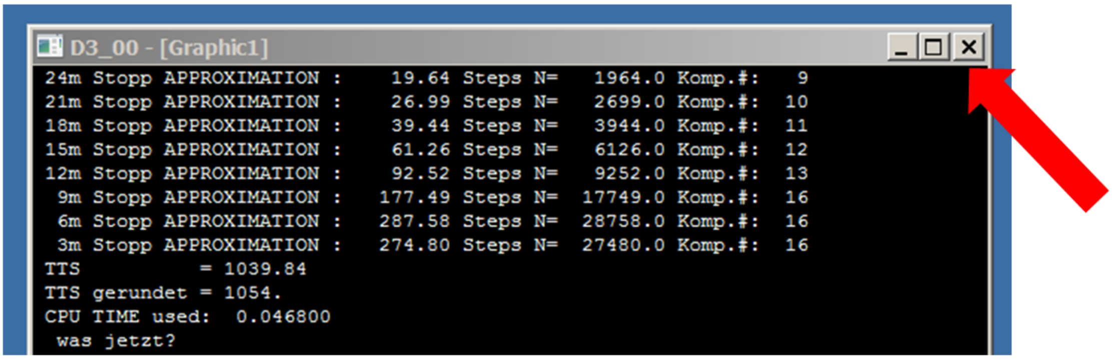
after download and extraction of the ZIP-archive DIVE could be run without any explicit installation or set up, only the protocol files are missing then.

Only if you want to use these, i.e. the run-time files, the features of the ASCII interface („F“), and, in the „Expert Mode“ the coeffcient matrices („NC“, „HC“) there must be a certain directory structure:

C:\DIVE\	new main-directory
C:\DIVE\PROG\	directory for the executable software, the *.EXE files
C:\DIVE\PROT\	directory for the run-times, the protocol-File PROTOCOL.TXT, the coefficient-matrices N2COEFF.TXT for Nitrogen and HECOEFF.TXT for Helium. If, at the very first start-up DIVE sees this directory, the PROTOCOL.TXT will be generated automatically. Hint: if you want to store calculated compartment values via the command „F“: put all these files at this particular place. Next hint: put there as well your back-up copies of N2COEFF.TXT and HECOEFF.TXT, best with self-documenting names, like: COEFF_ORG.TXT or COEFF_USN.TXT.

Hint, to top it:
if the program seems to be „hanging“ or a numerical calculation takes too long:

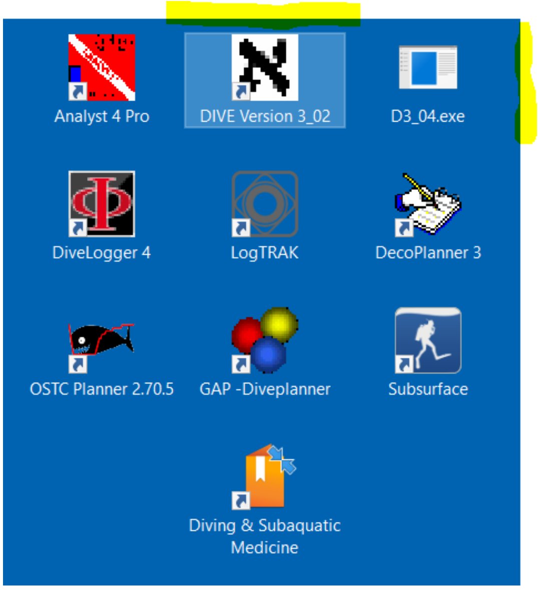
- a simple mouse-click on the „x“ of the window (pls. cf. the red arrow in the next picture);
- or, in the Task-Manager („Windows“-Button + „R“ → „taskmgr.exe“) and then stoping / cancelling the „DIVE“ processes or the application.



```
24m Stopp APPROXIMATION :    19.64 Steps N=    1964.0 Komp.#:    9
21m Stopp APPROXIMATION :    26.99 Steps N=    2699.0 Komp.#:   10
18m Stopp APPROXIMATION :    39.44 Steps N=    3944.0 Komp.#:   11
15m Stopp APPROXIMATION :    61.26 Steps N=    6126.0 Komp.#:   12
12m Stopp APPROXIMATION :    92.52 Steps N=    9252.0 Komp.#:   13
 9m Stopp APPROXIMATION :   177.49 Steps N=   17749.0 Komp.#:   16
 6m Stopp APPROXIMATION :   287.58 Steps N=   28758.0 Komp.#:   16
 3m Stopp APPROXIMATION :   274.80 Steps N=   27480.0 Komp.#:   16
TTS          = 1039.84
TTS gerundet = 1054.
CPU TIME used:   0.046800
 was jetzt?
```

7-1: Closing a window and cancelling the „DIVE“

In the ZIP-archive you will find all these coeffcient matrices as ASCII (*.TXT) -files, and as well, the icon favicon.ico: it is a hebrew „Aleph“, the first letter in a couple of semitic or proto-semitic alphabets, or like the „A“ in ALBI … ☺):



7-2: Aleph, the DIVE-icon

8 Automated „SET UP“

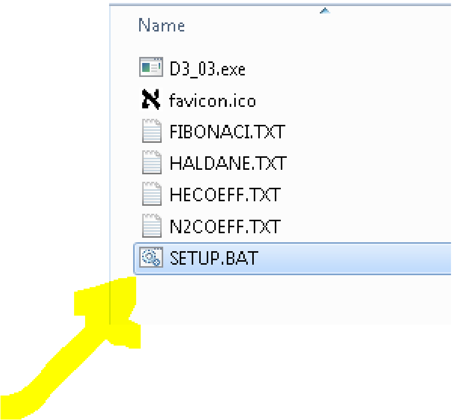
For a simplified and automated set up there is a tiny batch-file in the ZIP-archive with the name: SETUP.BAT, you can cancel it at any time with „strg c“ (= „CNTL C“):

```
@echo SET UP: DIVE Version 3
@echo Abbruch: jederzeit moeglich mit: strg c (CNTL C)
PAUSE
@ECHO OFF
REM ****************************************************
REM *                                                  *
```

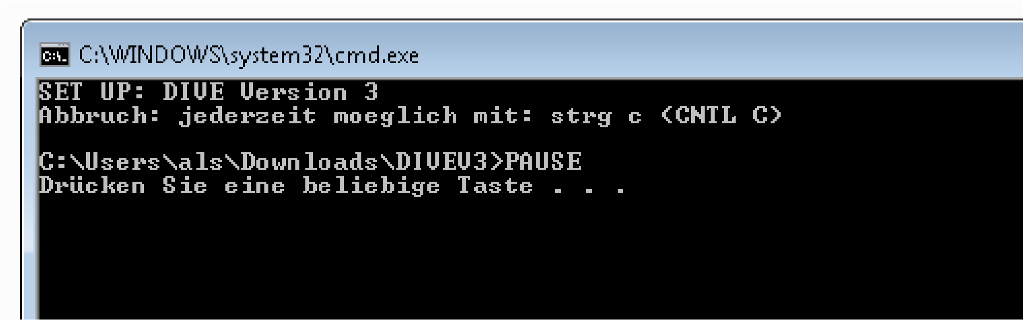
```
REM *    Erstellen der Verzeichnisse C:\DIVE          *
REM *    sowie:    C:\DIVE\Prog   (für das *.exe)     *
REM *    und:      C:\DIVE\Prot   (für PROTOCOL Files) *
REM *    und Kompartiment-Matrizen                    *
REM *                                                 *
REM ***************************************************
@echo on
md c:\DIVE
md c:\DIVE\Prog
md c:\DIVE\Prot
copy D3*.exe c:\DIVE\Prog /v
PAUSE
xcopy *.TXT c:\DIVE\Prot /v
PAUSE
@echo DIVE Version 3 installiert!
EXIT
```

Running of SETUP.BAT:

1) WIN + „R“, then key-in: „SETUP.BAT“, or:
2) WIN + „R“, then CMD, in the new window key in SETUP.BAT, or:
3) Double-click in any explorer display, pls.cf. the yellow arrow below:

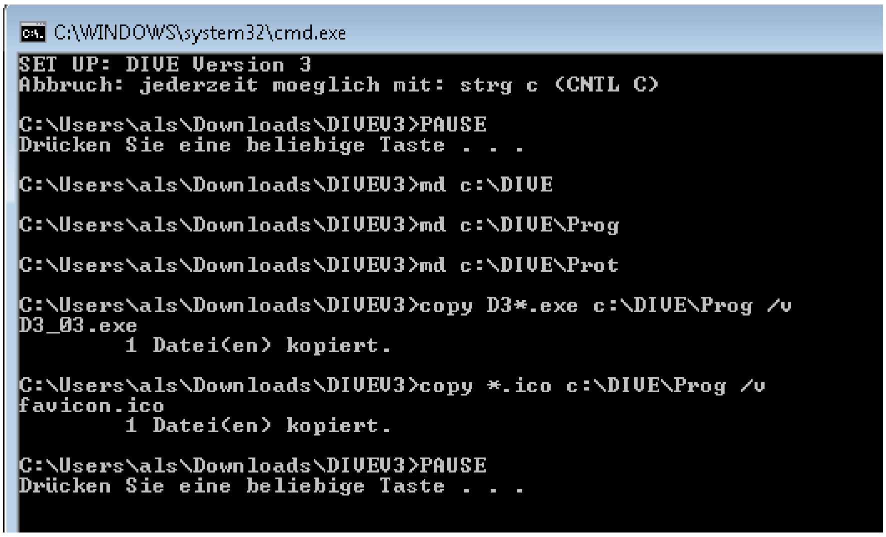


8-1: un-packed archive



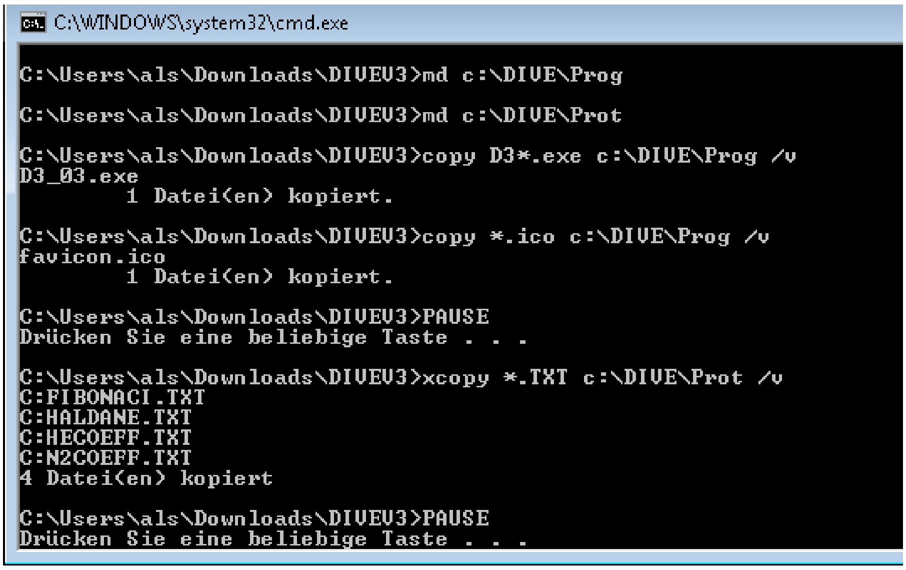
```
SET UP: DIVE Version 3
Abbruch: jederzeit moeglich mit: strg c (CNTL C)

C:\Users\als\Downloads\DIVEV3>PAUSE
Drücken Sie eine beliebige Taste . . .
```

8-2: the double-click starts „SETUP.BAT“



```
SET UP: DIVE Version 3
Abbruch: jederzeit moeglich mit: strg c (CNTL C)

C:\Users\als\Downloads\DIVEV3>PAUSE
Drücken Sie eine beliebige Taste . . .

C:\Users\als\Downloads\DIVEV3>md c:\DIVE

C:\Users\als\Downloads\DIVEV3>md c:\DIVE\Prog

C:\Users\als\Downloads\DIVEV3>md c:\DIVE\Prot

C:\Users\als\Downloads\DIVEV3>copy D3*.exe c:\DIVE\Prog /v
D3_03.exe
        1 Datei(en) kopiert.

C:\Users\als\Downloads\DIVEV3>copy *.ico c:\DIVE\Prog /v
favicon.ico
        1 Datei(en) kopiert.

C:\Users\als\Downloads\DIVEV3>PAUSE
Drücken Sie eine beliebige Taste . . .
```

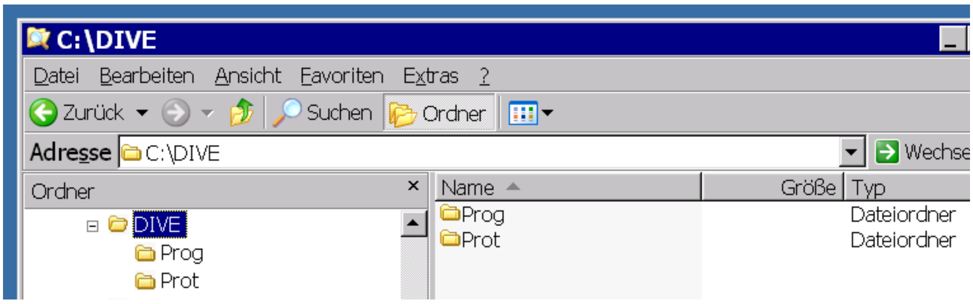
8-3: Step 1 of SETUP.BAT



```

C:\Users\als\Downloads\DIVEV3>md c:\DIVE\Prog

C:\Users\als\Downloads\DIVEV3>md c:\DIVE\Prot

C:\Users\als\Downloads\DIVEV3>copy D3*.exe c:\DIVE\Prog /v
D3_03.exe
        1 Datei(en) kopiert.

C:\Users\als\Downloads\DIVEV3>copy *.ico c:\DIVE\Prog /v
favicon.ico
        1 Datei(en) kopiert.

C:\Users\als\Downloads\DIVEV3>PAUSE
Drücken Sie eine beliebige Taste . . .

C:\Users\als\Downloads\DIVEV3>xcopy *.TXT c:\DIVE\Prot /v
C:FIBONACI.TXT
C:HALDANE.TXT
C:HECOEFF.TXT
C:N2COEFF.TXT
4 Datei(en) kopiert

C:\Users\als\Downloads\DIVEV3>PAUSE
Drücken Sie eine beliebige Taste . . .
```

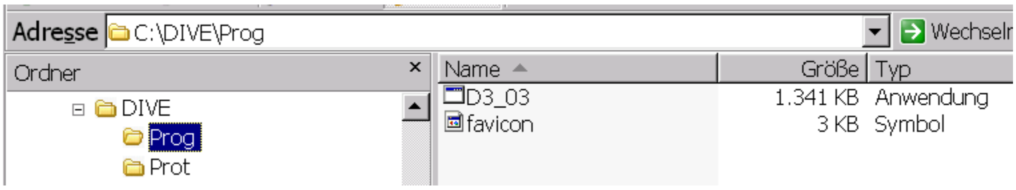
8-4: Step 2 of SETUP.BAT and EXIT

If, manually or via SETUP.BAT, after sucessfull installation the directories should like like that:



Name	Größe	Typ
Prog		Dateiordner
Prot		Dateiordner

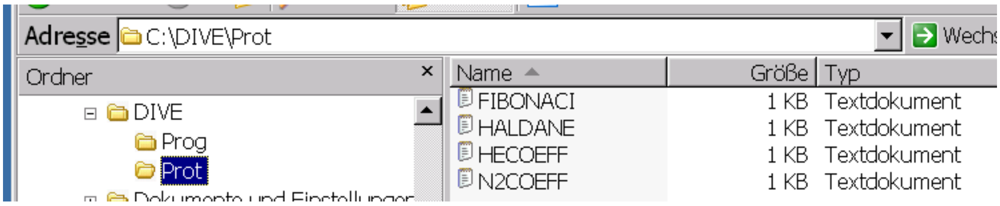
8-5: directories after set up



Adresse C:\DIVE\Prog

Name	Größe	Typ
D3_03	1.341 KB	Anwendung
favicon	3 KB	Symbol

8-6: Contents of C:\DIVE**Prog**



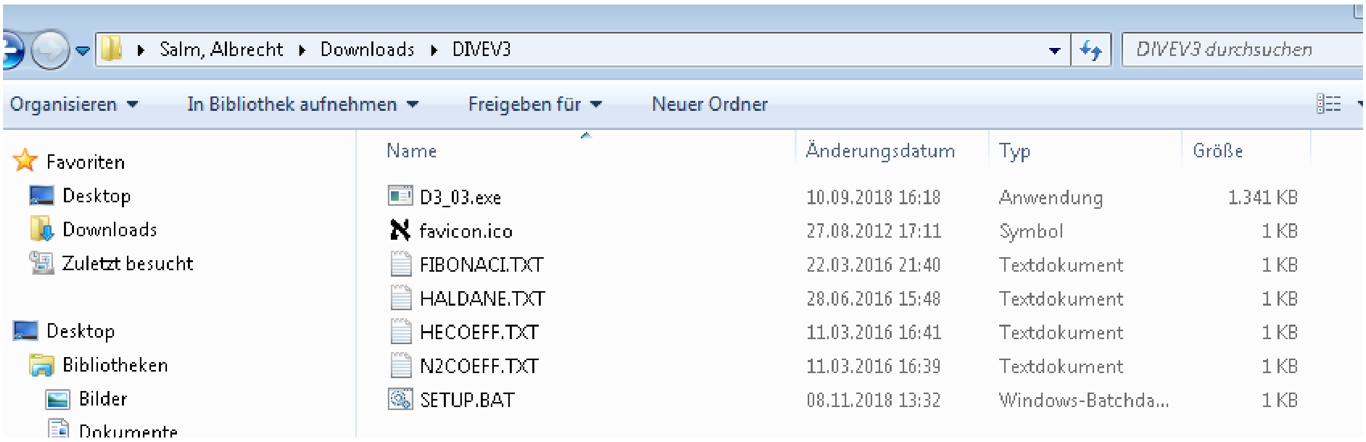
Adresse C:\DIVE\Prot

Name	Größe	Typ
FIBONACI	1 KB	Textdokument
HALDANE	1 KB	Textdokument
HECOEFF	1 KB	Textdokument
N2COEFF	1 KB	Textdokument

8-7: Contents of C:\DIVE**Prot**

9 Contents of the complete ZIP-archive:

- a 64-Bit Version of DIVE D3_xx.exe
- a N_2-coefficient matrix as paradigm
- a He-coefficient matrix as paradigm
- the SETUP.BAT File



Name	Änderungsdatum	Typ	Größe
D3_03.exe	10.09.2018 16:18	Anwendung	1.341 KB
favicon.ico	27.08.2012 17:11	Symbol	1 KB
FIBONACI.TXT	22.03.2016 21:40	Textdokument	1 KB
HALDANE.TXT	28.06.2016 15:48	Textdokument	1 KB
HECOEFF.TXT	11.03.2016 16:41	Textdokument	1 KB
N2COEFF.TXT	11.03.2016 16:39	Textdokument	1 KB
SETUP.BAT	08.11.2018 13:32	Windows-Batchda...	1 KB

9-1: Contents of the complete ZIP-archive and downloaded to: „Downloads\DIVEV3\“

The following file-parameters apply to the topical ZIP-archive:

	64 Bit topical version: 3_11
Archive- Name:	DIVEV3.zip
From (Date, time):	**17.01.2025, 19:57**
Size (Bytes):	931.037
MD5:	1F48ED436513F77E40300B8BD765E956
	CRC / SHA check sums: pls. cf. further down

Table 1: File-Parameters of the ZIP-archives

The MD5 are simple check-sums: if they do not match, then „something“ had happend to your file, either during download or on your PC …

SHA1:
949F5F2795DCB6AF335244B623DC65B66BFD5573
SHA256:
ED881A26CF3C67A2D59FF1732D45F5D92523C785C9417C3B3BB710521FD2F308

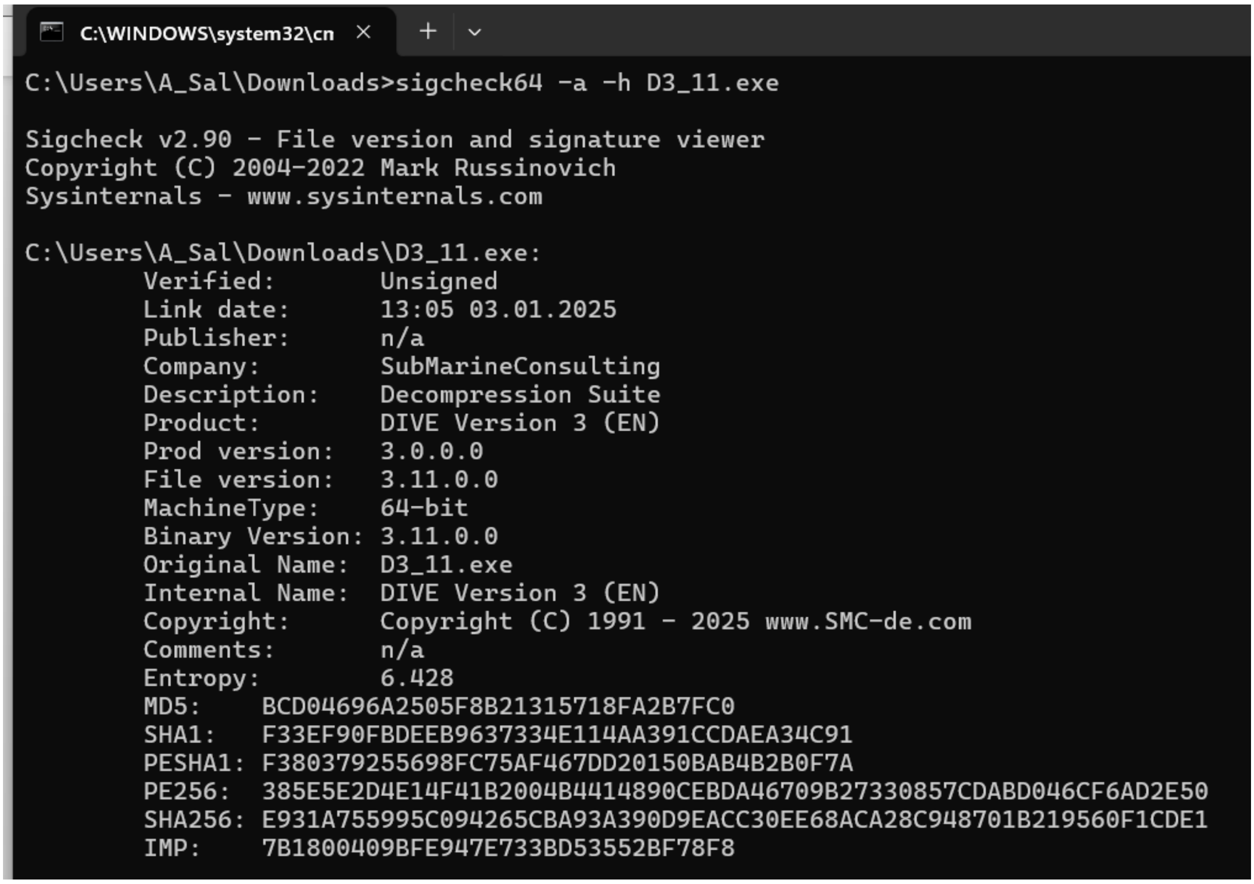
9-2: more checksums

There are many MD5-checksum programmes available for free, for eg. sigcheck64.exe:

- from the official Microsoft Sysinternals page (https://live.sysinternals.com/)
- https://live.sysinternals.com/sigcheck64.exe

sigcheck exe does not need any installation:

sigcheck64 **-a -h** <filename> shows a lot of info, here with the paradigm of the topical D3_11.exe from the BETA site:



```
C:\Users\A_Sal\Downloads>sigcheck64 -a -h D3_11.exe

Sigcheck v2.90 - File version and signature viewer
Copyright (C) 2004-2022 Mark Russinovich
Sysinternals - www.sysinternals.com

C:\Users\A_Sal\Downloads\D3_11.exe:
        Verified:       Unsigned
        Link date:      13:05 03.01.2025
        Publisher:      n/a
        Company:        SubMarineConsulting
        Description:    Decompression Suite
        Product:        DIVE Version 3 (EN)
        Prod version:   3.0.0.0
        File version:   3.11.0.0
        MachineType:    64-bit
        Binary Version: 3.11.0.0
        Original Name:  D3_11.exe
        Internal Name:  DIVE Version 3 (EN)
        Copyright:      Copyright (C) 1991 - 2025 www.SMC-de.com
        Comments:       n/a
        Entropy:        6.428
        MD5:    BCD04696A2505F8B21315718FA2B7FC0
        SHA1:   F33EF90FBDEEB9637334E114AA391CCDAEA34C91
        PESHA1: F380379255698FC75AF467DD20150BAB4B2B0F7A
        PE256:  385E5E2D4E14F41B2004B4414890CEBDA46709B27330857CDABD046CF6AD2E50
        SHA256: E931A755995C094265CBA93A390D9EACC30EE68ACA28C948701B219560F1CDE1
        IMP:    7B1800409BFE947E733BD53552BF78F8
```

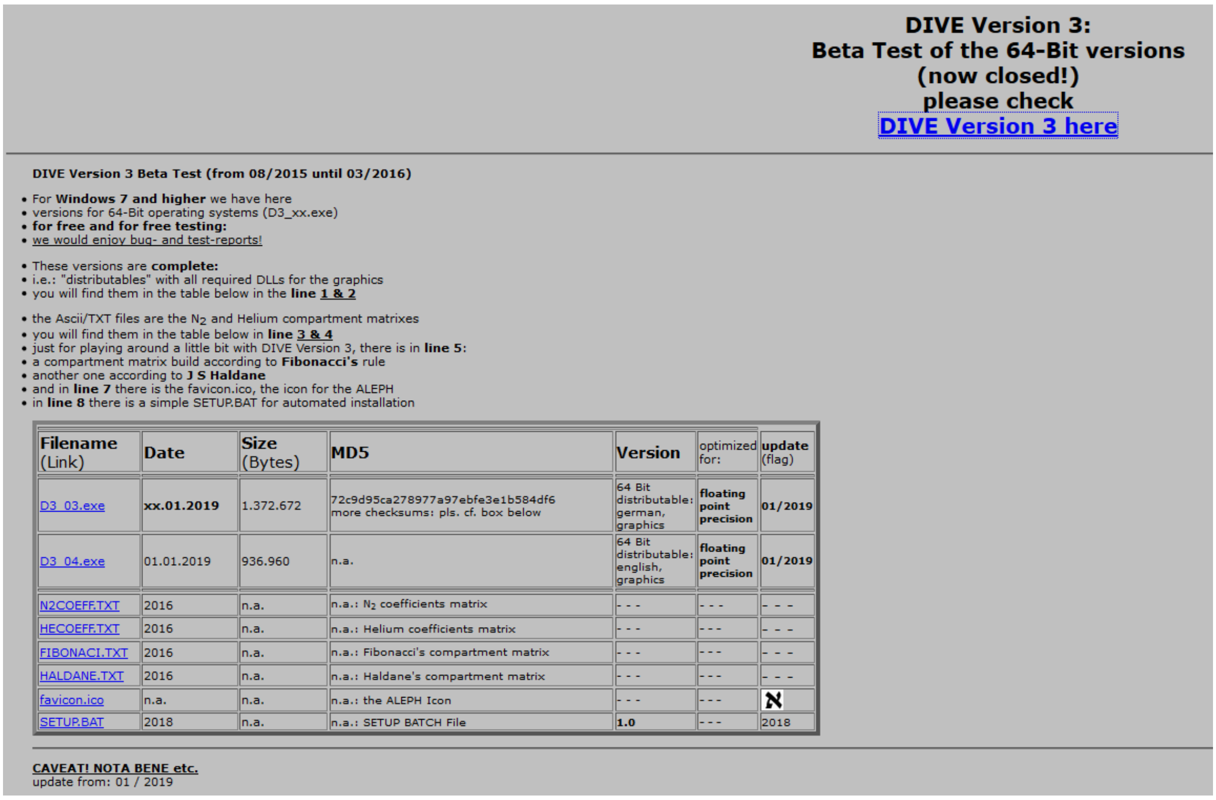
9-3: sigcheck from MS sysinternals with topical D3_11.exe

10 the DIVE V3 BETA Test Site

All files could be downloaded individually from the former DIVE V3 BETA Test site:

https://www.divetable.info/beta/index_e.htm

This was the BETA Test site from 08/2015 until 03/2016: now you could download all the required files individually in their latest versions:



DIVE Version 3:
Beta Test of the 64-Bit versions
(now closed!)
please check
DIVE Version 3 here

DIVE Version 3 Beta Test (from 08/2015 until 03/2016)

- For **Windows 7 and higher** we have here
- versions for 64-Bit operating systems (D3_xx.exe)
- **for free and for free testing:**
- we would enjoy bug- and test-reports!

- These versions are **complete:**
- i.e.: "distributables" with all required DLLs for the graphics
- you will find them in the table below in the **line 1 & 2**

- the Ascii/TXT files are the N_2 and Helium compartment matrixes
- you will find them in the table below in **line 3 & 4**
- just for playing around a little bit with DIVE Version 3, there is in **line 5**:
- a compartment matrix build according to **Fibonacci's** rule
- another one according to **J S Haldane**
- and in **line 7** there is the favicon.ico, the icon for the ALEPH
- in **line 8** there is a simple SETUP.BAT for automated installation

Filename (Link)	**Date**	**Size** (Bytes)	**MD5**	**Version**	optimized for:	**update** (flag)
D3_03.exe	**xx.01.2019**	1.372.672	72c9d95ca278977a97ebfe3e1b584df6 more checksums: pls. cf. box below	64 Bit distributable: german, graphics	**floating point precision**	**01/2019**
D3_04.exe	01.01.2019	936.960	n.a.	64 Bit distributable: english, graphics	**floating point precision**	**01/2019**
N2COEFF.TXT	2016	n.a.	n.a.: N_2 coefficients matrix	- - -	- - -	- - -
HECOEFF.TXT	2016	n.a.	n.a.: Helium coefficients matrix	- - -	- - -	- - -
FIBONACI.TXT	2016	n.a.	n.a.: Fibonacci's compartment matrix	- - -	- - -	- - -
HALDANE.TXT	2016	n.a.	n.a.: Haldane's compartment matrix	- - -	- - -	- - -
favicon.ico	n.a.	n.a.	n.a.: the ALEPH Icon	- - -	- - -	א
SETUP.BAT	2018	n.a.	n.a.: SETUP BATCH File	**1.0**	- - -	2018

CAVEAT! NOTA BENE etc.
update from: 01 / 2019

10-1: DIVE V3 BETA Test Site

11 tested Operating-Systems

D3_xx, 64 Bit, has been tested for (02/2025):
Windows 7, 8.1, 10, 11.

12 Conventions

In this manual we reframe all inputs into the software with double quotes, for eg. if we try to convince DIVE to make a deco stop in 4.5 m depth for 7. minutes:

„e“ „4.5“ „7.“

Ambient (air-) pressure is in mbar, depth in meters & centimeters (m.cm) (default: water density of fresh water at a water temperature of 20 ° C), time is in minutes, parts (fractions) dimensionless, %CNS is the percentage of the NOAA CNS O_2-toxicity dose, the OTU is an absolute dose, **HT** is a half-life time in minutes..

References or sources and hints for further reading are often designated with a number in square brackets, for eg. the book „Decompression Sickness“ from Hills, B.A **[102]**. This number refers to the list of useful books:

https://www.divetable.eu/BOOKS/index_e.htm

At the entry 102 you will find usually more information, like the cover and a table of contents.

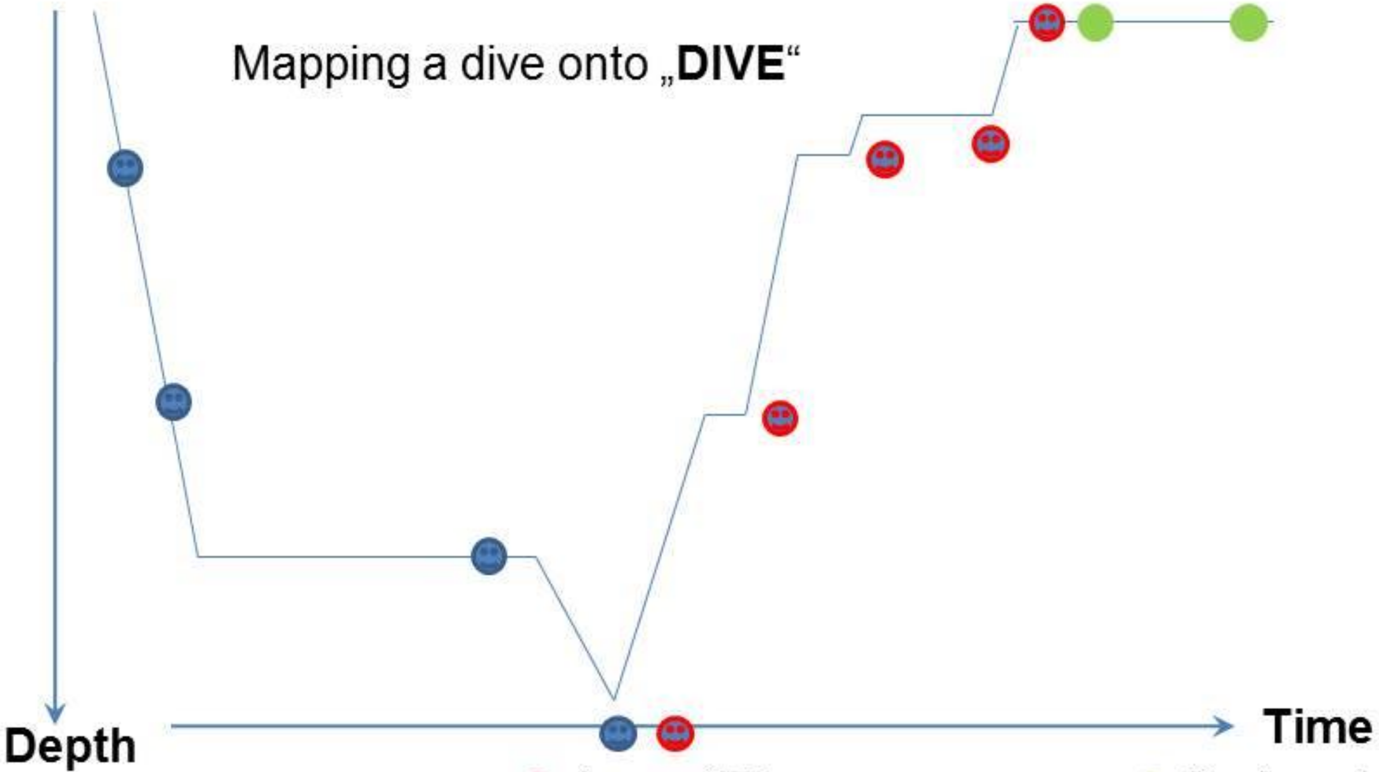
With the word **deco** we imply not only decompression as a procedure (reduction of ambient pressure, ascent) per se but sometimes as well a decompression stop; **SI** is the standard abbreviation for surface interval, a **MIX** is any breathable gasmix, be at EAN/Nitrox, Trimix or Heliox or whatever.

Nitrogen is designated as $\mathbf{N_2}$, Helium as **He** and Oxygen as $\mathbf{O_2}$, the usual scientific symbols.

More abbreviations: the famous United States Navy appears here as „USN“, their „Experimental Diving Unit“ as „NEDU“, DAN is the Divers Alert Network.

The idea behind DIVE is to control each stage of a dive and giving the appropriate information as output, very much the same, as a dive computer does. So we could not just key in regular box profiles like from a standard dive table, but any, arbitrarily small steps in time or depth or oxygen-contents:

Mapping a dive onto „**DIVE**“



Bottom Phase

Commands / Parameters, eq.:

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

„a“ „p“ „z“ ………..

Ascent Phase

Commands / Parameters, eq.:

„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, eq.:

„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 -> ●

12-1: Mapping a dive onto „DIVE“

13 Overview of the commands

Usually prior to the very first run of DIVE you get a couple of warnings, depending on your OS, your user rights and the security configuration; the warnings you may safely ignore, here just an overview of the thumbnails from a german PC, for reference:

Datei öffnen - Sicherheitswarnung

Der Herausgeber konnte nicht verifiziert werden. Möchten Sie diese Software ausführen?

Name: C:\Users\ALBI\Downloads\D301_64.exe
Herausgeber: **Unbekannter Herausgeber**
Typ: Anwendung
Von: C:\Users\ALBI\Downloads\D301_64.exe

☑ Vor dem Öffnen dieser Datei immer bestätigen

Diese Datei verfügt über keine gültige digitale Signatur, die den Herausgeber verifiziert. Sie sollten nur Software ausführen, die von Herausgebern stammt, denen Sie vertrauen. Welche Software kann ausgeführt werden?

13-1: Safety Warning: WIN7

SmartScreen-Filter - Internet Explorer

Das Programm kann auf dem Computer Schaden anrichten.

Herausgeber: Unbekannt
Name: D3_03.exe

Der SmartScreen-Filter hat gemeldet, dass dieses Programm nicht häufig heruntergeladen wird und nicht vom Autor signiert ist.

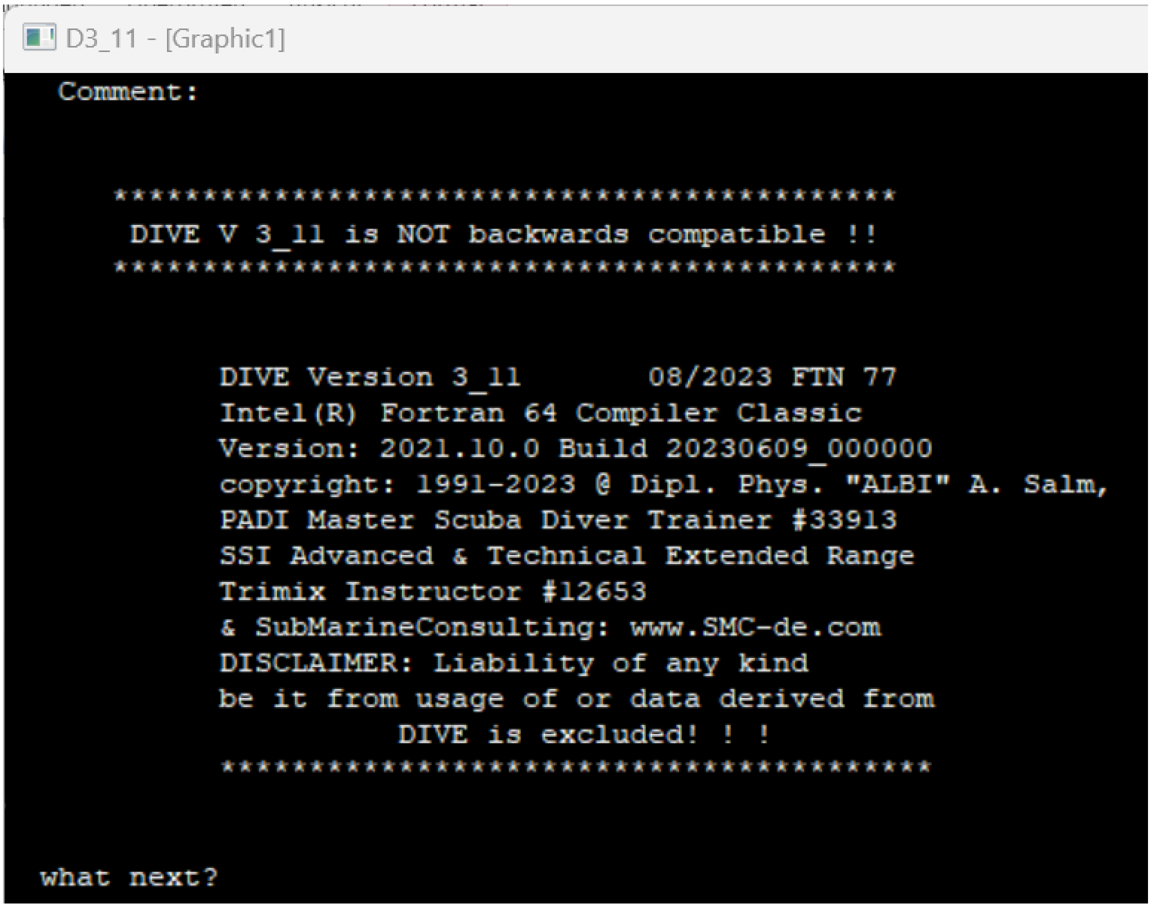
Wenn Sie das Programm unaufgefordert, in einem Link oder in einer Anlage erhalten haben, deutet dies möglicherweise auf den Versuch hin, Sie zu täuschen. Es wird daher empfohlen, das Programm zu löschen.

13-2: SmartScreen-Filter (IE)

Der Computer wurde durch Windows geschützt

Von Windows Defender SmartScreen wurde der Start einer unbekannten App verhindert. Die Ausführung dieser App stellt u. U. ein Risiko für den PC dar.

13-3: WIN10 / Defender



```
 Comment:


    ********************************************
     DIVE V 3_11 is NOT backwards compatible !!
    ********************************************



          DIVE Version 3_11       08/2023 FTN 77
          Intel(R) Fortran 64 Compiler Classic
          Version: 2021.10.0 Build 20230609_000000
          copyright: 1991-2023 @ Dipl. Phys. "ALBI" A. Salm,
          PADI Master Scuba Diver Trainer #33913
          SSI Advanced & Technical Extended Range
          Trimix Instructor #12653
          & SubMarineConsulting: www.SMC-de.com
          DISCLAIMER: Liability of any kind
          be it from usage of or data derived from
                    DIVE is excluded! ! !
          ****************************************



what next?
```

13-4: BANNER / welcome message

If you got over this stuff, you see the welcome message. If you had had run the SETUP previously, you will see before a prompt with the possibility of entering a comment, pls. cf. the red arrow above. This particular information is used in the PROTOCOL.TXT file as a delimitation between the various run-times you produce by using DIVE.

With the ubiquitous:

what next?

DIVE asks for the next command. Now you could key-in the mnemonics from the basic commands, pls. cf. the list below, input is always possible in CAPITAL or small letters. After a typo it says just:

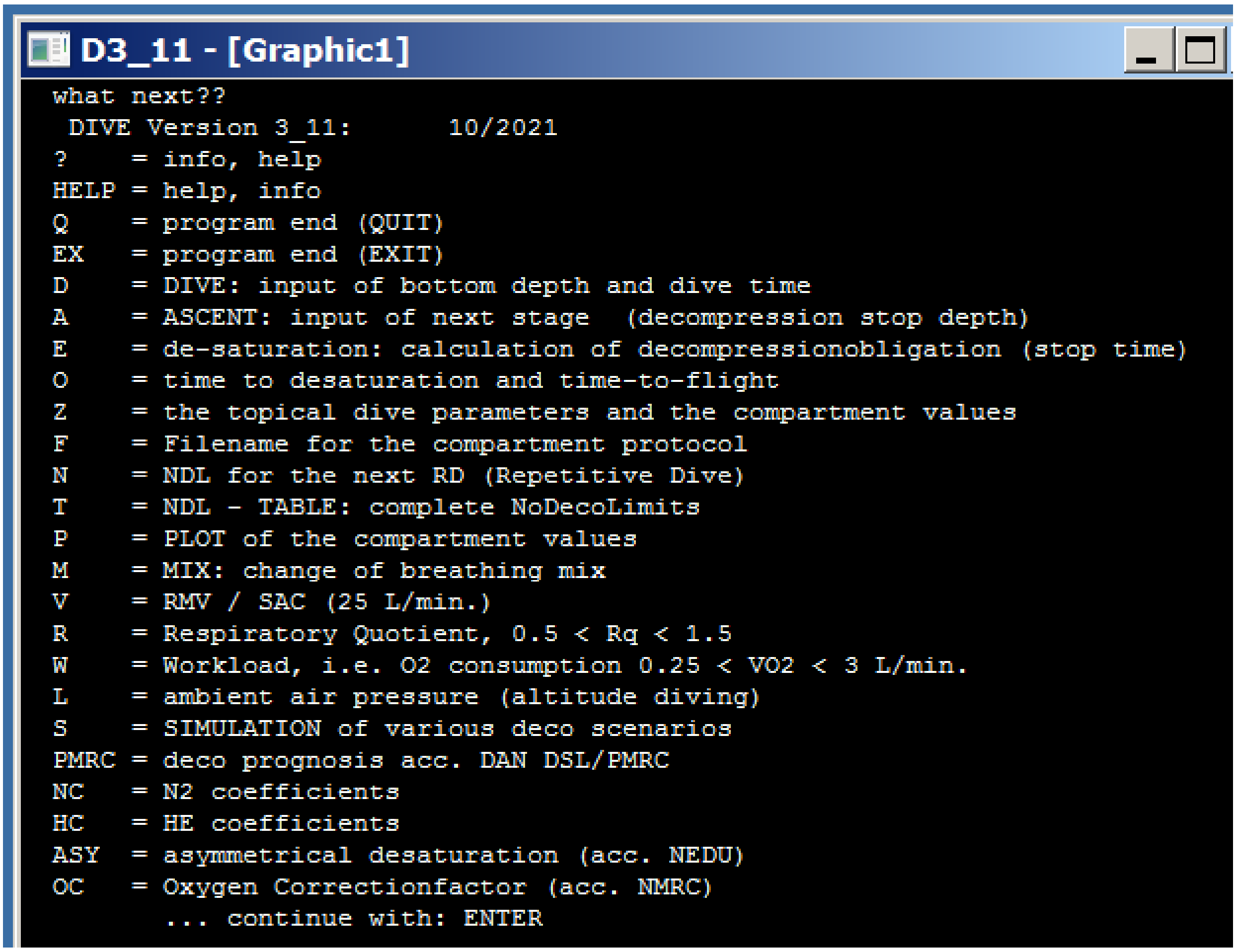
what???

With the input of a question mark:

"?"
or, alternatively:

„help“

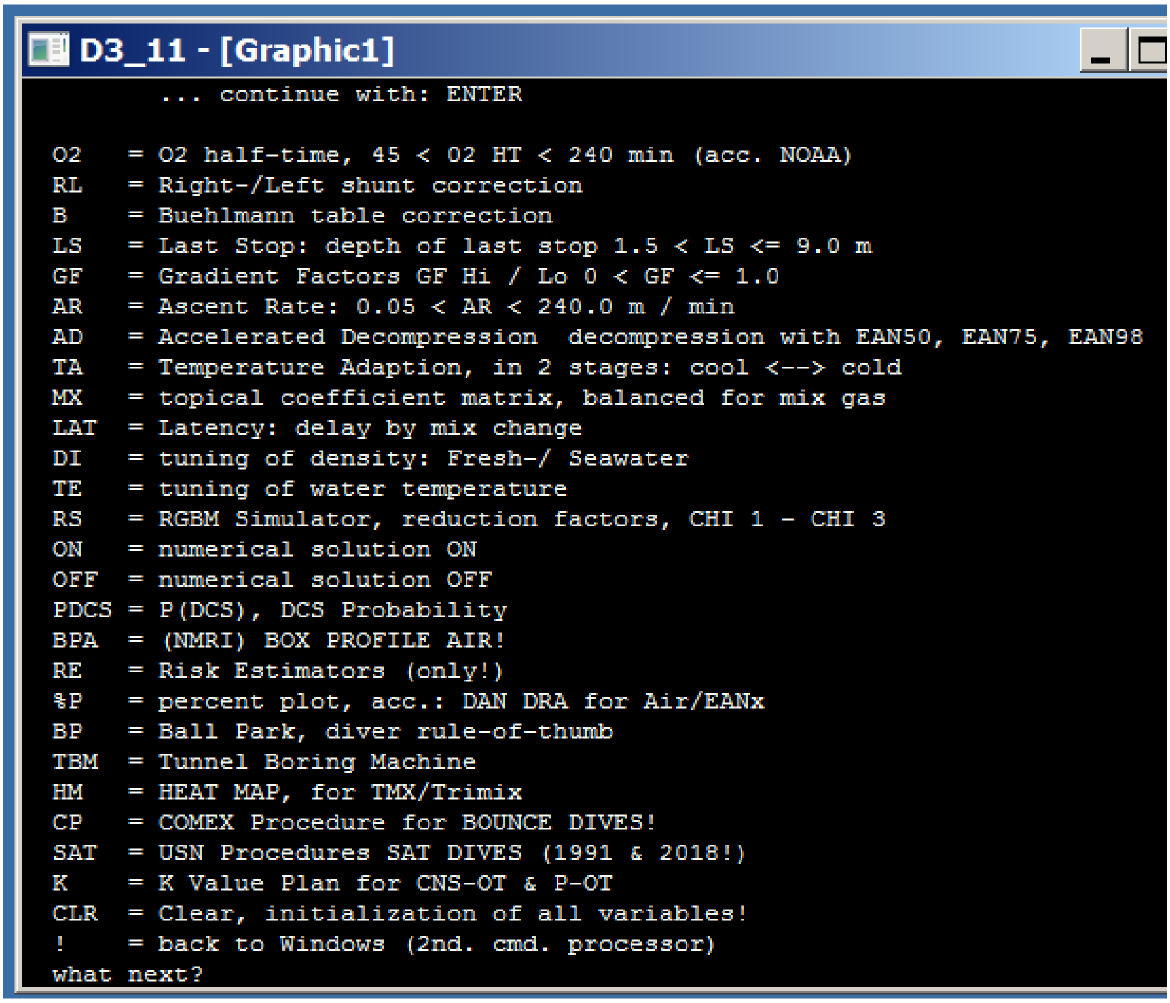
you will see the following 2 screens:



```
what next??
 DIVE Version 3_11:      10/2021
?    = info, help
HELP = help, info
Q    = program end (QUIT)
EX   = program end (EXIT)
D    = DIVE: input of bottom depth and dive time
A    = ASCENT: input of next stage  (decompression stop depth)
E    = de-saturation: calculation of decompressionobligation (stop time)
O    = time to desaturation and time-to-flight
Z    = the topical dive parameters and the compartment values
F    = Filename for the compartment protocol
N    = NDL for the next RD (Repetitive Dive)
T    = NDL - TABLE: complete NoDecoLimits
P    = PLOT of the compartment values
M    = MIX: change of breathing mix
V    = RMV / SAC (25 L/min.)
R    = Respiratory Quotient, 0.5 < Rq < 1.5
W    = Workload, i.e. O2 consumption 0.25 < VO2 < 3 L/min.
L    = ambient air pressure (altitude diving)
S    = SIMULATION of various deco scenarios
PMRC = deco prognosis acc. DAN DSL/PMRC
NC   = N2 coefficients
HC   = HE coefficients
ASY  = asymmetrical desaturation (acc. NEDU)
OC   = Oxygen Correctionfactor (acc. NMRC)
       ... continue with: ENTER
```

13-5: first screen with the commands

After hitting the „Enter“-key („return“, data release) comes the 2nd.:



```
         ... continue with: ENTER

 O2   = O2 half-time, 45 < O2 HT < 240 min (acc. NOAA)
 RL   = Right-/Left shunt correction
 B    = Buehlmann table correction
 LS   = Last Stop: depth of last stop 1.5 < LS <= 9.0 m
 GF   = Gradient Factors GF Hi / Lo 0 < GF <= 1.0
 AR   = Ascent Rate: 0.05 < AR < 240.0 m / min
 AD   = Accelerated Decompression  decompression with EAN50, EAN75, EAN98
 TA   = Temperature Adaption, in 2 stages: cool <--> cold
 MX   = topical coefficient matrix, balanced for mix gas
 LAT  = Latency: delay by mix change
 DI   = tuning of density: Fresh-/ Seawater
 TE   = tuning of water temperature
 RS   = RGBM Simulator, reduction factors, CHI 1 - CHI 3
 ON   = numerical solution ON
 OFF  = numerical solution OFF
 PDCS = P(DCS), DCS Probability
 BPA  = (NMRI) BOX PROFILE AIR!
 RE   = Risk Estimators (only!)
 %P   = percent plot, acc.: DAN DRA for Air/EANx
 BP   = Ball Park, diver rule-of-thumb
 TBM  = Tunnel Boring Machine
 HM   = HEAT MAP, for TMX/Trimix
 CP   = COMEX Procedure for BOUNCE DIVES!
 SAT  = USN Procedures SAT DIVES (1991 & 2018!)
 K    = K Value Plan for CNS-OT & P-OT
 CLR  = Clear, initialization of all variables!
 !    = back to Windows (2nd. cmd. processor)
 what next?
```

13-6: 2nd. screen of the commands

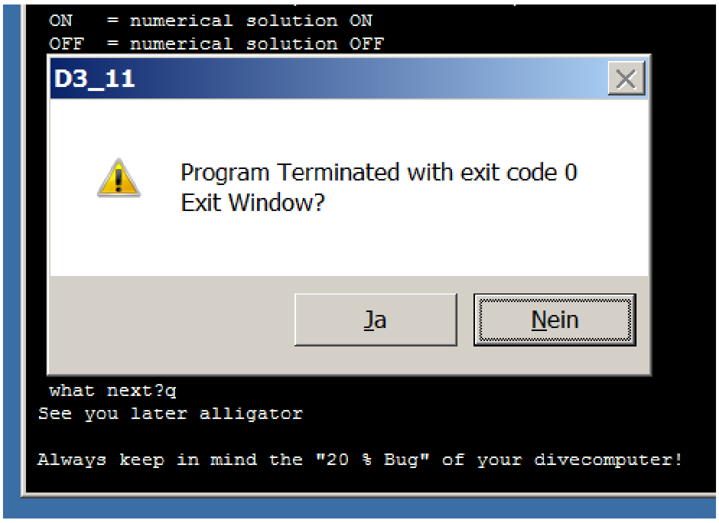
Short Explanations to the commands:

? or HELP	the above 2 help screens
Q oder EX	program end (like: QUIT or EXIT)
D	start of the simulation (like: DIVE), input of bottom depth in m.cm (with the decimal point) and the dive time in minutes
A	ASCENT: input of any arbitrary depth, lower than the ceiling
E	de-saturation: calculation of a deco-time at any arbitrary deco-step
O	surface interval: time to complete de-saturation and time-to-flight
Z	show all parameters: the topical values of the 16 compartiments, max. depth (trailing pointer), topical depth, time at this depth, complete dive time and the rest of the parameters like Rq, SAC, GF Hi / Lo, depths of the first and last stops, ambient air pressure, etc . … on 2 pages
F	Filename for the protocol file for the above cited parameters. This is not the dive protocol, the run time. This file could be stored (W = Write) or retrieved again (R = READ)
N	NDL, the „no-decompression-limits“ for a single repetitive dive, only during SI
T	TABLE with all „no-decompression-limits“ (NDL) for a certain air/ean mix, in the depth rage of 6 - 63 m
P	PLOT (everything …), leaving this graphic screen with: Return
M	MIX: change of breathing mix, input of Oxygen and then the Helium fractions; balance N_2-fraction
V	SAC (surface air consumption), SAC default = 25 L / min.

R	respiratory quotient Rq: $0.5 < Rq < 1.5$
W	workload und thus: oxygen consumption VO_2: $0.25 < VO_2 < 3$ L/min.
L	change of ambient air pressure, e.g. for altitude diving
S	simulation of varios deco scenarious: conservativisms factors and percentage safety-surcharges
PMRC	deco prognosis according to DAN / DSL PMRC
NC	expert mode: the N_2-coefficient matrix (TAU, A, B) can be changed and as well, per compartment, the gradient factors GF HI and GF LO
HC	dito, as per above, but for Helium
ASY	asymmetrical de-saturation, during bottom time and during SI, according to the U.S. Navy EDU correction procedures
OC	the Oxygen Correction factors, during bottom time and as a table during SI; based on the NMRI reduction factors
O2	the O_2 half-life times for %CNS Ox-Tox doses, the usual 90 min can be adapted: $45 <= O_2$ HT <= 240 min
RL	pulmonary right-to-left shunt, a correction factor only during SI
BSC	Buehlmann Shunt Correction (for a R-/L-Shunt), also for Helium
B	Buehlmann table correction
BSC	Buehlmann Shunt Correction
LS	Last Stop: depth of the last deco stop: 1.5 <= LS <= 9.0 m
GF	Gradient Factors: input of the GF HI and GF LO; with: 0 < GF <= 1.0, and GF HI > GF LO!
AR	the ascent rate can be adapted from 0.1 (sat.-dive) to 200 m/min (apnea)
AD	accelerated deco: automated prognosis with EAN. The mixes: EAN50, EAN75 and EAN98 will be factored in @ MOD ca. 1.6 atm pO_2
TA	Temperature Adaption according to ZH-L 8 ADT: the perfusion reduction through coldness could be adapted in 2 stages: cool or cold
MX	Matrix: for all calculations involving mix gas you could scrutinize the topical coeffcients (a-, b-, HT) at run-time
LAT	Latency: physiologic time-lag at a mix change during deco through the finite relation: perfusion/ventilation in the lung
DI	adaption of the specific density for fresh- or sea-water
TE	adaption of the water temperature and thus: calculation of the density anomaly
RS	RGBM Simulator: matrix of the „bubble factors“
ON	numerical solution: ON
OFF	numerical solution: OFF
PDCS	P(DCS) = Probability of Decompressionsickness
BPA	Box Profile Air-method from NMRI
RE	risk „estimators“for EOD & OTF methods
%P	percent plot, according to DAN DRA, the „Decompression Risk Analysis“
BP	divers „Ball Parks“
TBM	tunnel boring machine (basically german)
HM	heat map for TMX / trimix
CP	COMEX procedure, but only for bounce dives
SAT	USN / MT92 / COMEX / N-15 saturation procedures
K	K value plan for CNS- & P-OT
DS	deco stress indices: PrT and DCIEM „I“
CNVR	conversion of the usual pressure units
CLR	CLeaR: variables at run-time are set back to their defaults
!	back to windows. With „EXIT“ you could leave this secondary command processor and you will fall back to DIVE

Clearly, not all commands could be used at any time: for eg. "T", "N" or "RL" is useless during the dive, it makes only sense during SI. Vice-versa "S" or "PMRC" will not work during SI: in all these situations, DIVE will simply not react.

During finishing work with DIVE there will be a friendly reminder of the measurement error, which is afflicted with ALL measurements, and at the annoying law of error-propagation. Then there is the final question from your OS, asking with an pop-up box if you want to leave this window: just confirm by hitting the JA (= „Yes“) button:



```
 ON   = numerical solution ON
 OFF  = numerical solution OFF
```

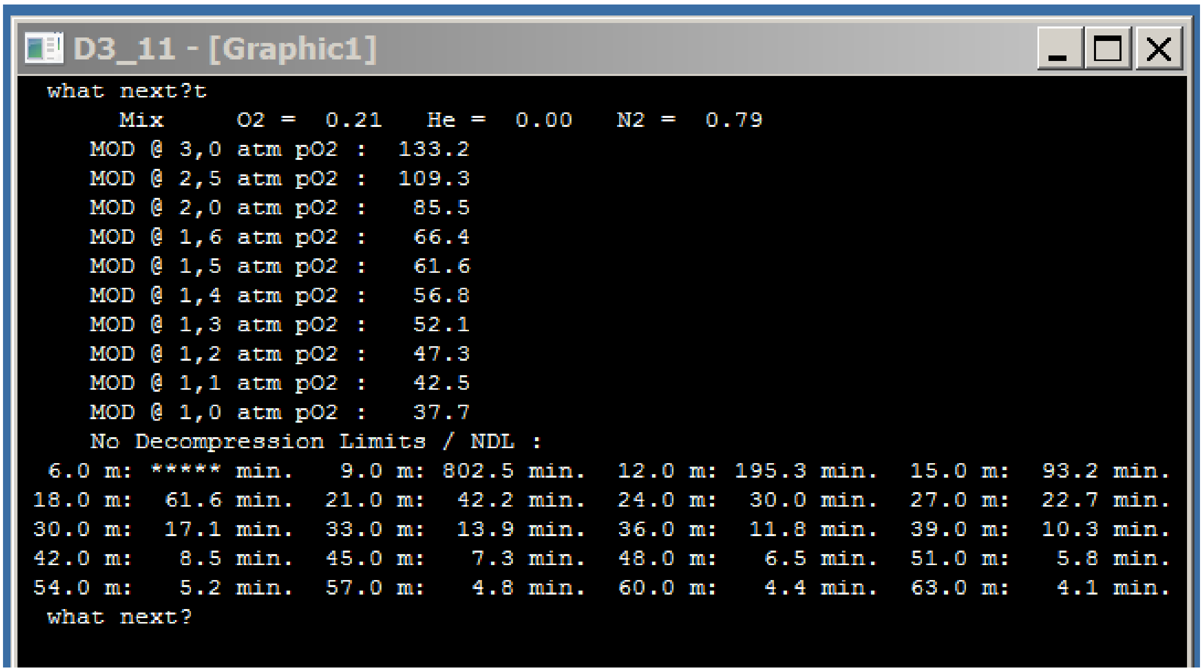
Program Terminated with exit code 0
Exit Window?

```
 what next?q
See you later alligator

Always keep in mind the "20 % Bug" of your divecomputer!
```

13-7: bye-bye messages

14 NDL tables (only for Air and NITROX / EANx)

A real easy excercise is the generation of complete NDL („No Decompression Limits“) tables for various air or EANx mixes via "T":

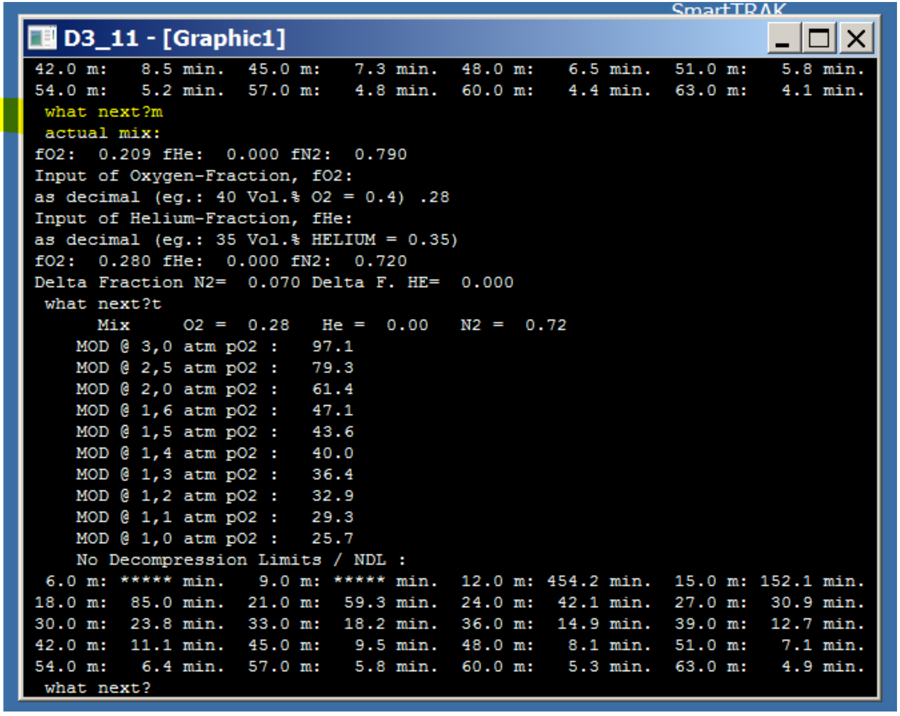


```
 what next?t
      Mix      O2 =  0.21   He =  0.00   N2 =  0.79
    MOD @ 3,0 atm pO2 :  133.2
    MOD @ 2,5 atm pO2 :  109.3
    MOD @ 2,0 atm pO2 :   85.5
    MOD @ 1,6 atm pO2 :   66.4
    MOD @ 1,5 atm pO2 :   61.6
    MOD @ 1,4 atm pO2 :   56.8
    MOD @ 1,3 atm pO2 :   52.1
    MOD @ 1,2 atm pO2 :   47.3
    MOD @ 1,1 atm pO2 :   42.5
    MOD @ 1,0 atm pO2 :   37.7
    No Decompression Limits / NDL :
 6.0 m: ***** min.   9.0 m: 802.5 min.  12.0 m: 195.3 min.  15.0 m:   93.2 min.
18.0 m:   61.6 min.  21.0 m:  42.2 min.  24.0 m:  30.0 min.  27.0 m:   22.7 min.
30.0 m:   17.1 min.  33.0 m:  13.9 min.  36.0 m:  11.8 min.  39.0 m:   10.3 min.
42.0 m:    8.5 min.  45.0 m:   7.3 min.  48.0 m:   6.5 min.  51.0 m:    5.8 min.
54.0 m:    5.2 min.  57.0 m:   4.8 min.  60.0 m:   4.4 min.  63.0 m:    4.1 min.
 what next?
```

14-1: NDL table for air

First you will see the used mix at run-time and a couple of different MODs, the „Maximum Operation Depth“ for $pO_{2,\ MAX!}$ from 3.0 down to 1.0 atm (yes, yes, the pro’s do not stop @1,6).

Next easy exercise: maybe you would like to check the NOAA Nitrox Tables for EAN28.
With the following inputs this is a piece of cake :
„m“ „0.28“ „0.0“ „t“ :



```
42.0 m:   8.5 min.  45.0 m:   7.3 min.  48.0 m:   6.5 min.  51.0 m:   5.8 min.
54.0 m:   5.2 min.  57.0 m:   4.8 min.  60.0 m:   4.4 min.  63.0 m:   4.1 min.
 what next?m
 actual mix:
fO2:  0.209 fHe:  0.000 fN2:  0.790
Input of Oxygen-Fraction, fO2:
as decimal (eg.: 40 Vol.% O2 = 0.4) .28
Input of Helium-Fraction, fHe:
as decimal (eg.: 35 Vol.% HELIUM = 0.35)
fO2:  0.280 fHe:  0.000 fN2:  0.720
Delta Fraction N2=  0.070 Delta F. HE=  0.000
 what next?t
      Mix     O2 =  0.28   He =  0.00   N2 =  0.72
    MOD @ 3,0 atm pO2 :   97.1
    MOD @ 2,5 atm pO2 :   79.3
    MOD @ 2,0 atm pO2 :   61.4
    MOD @ 1,6 atm pO2 :   47.1
    MOD @ 1,5 atm pO2 :   43.6
    MOD @ 1,4 atm pO2 :   40.0
    MOD @ 1,3 atm pO2 :   36.4
    MOD @ 1,2 atm pO2 :   32.9
    MOD @ 1,1 atm pO2 :   29.3
    MOD @ 1,0 atm pO2 :   25.7
    No Decompression Limits / NDL :
 6.0 m: ***** min.   9.0 m: ***** min.  12.0 m: 454.2 min.  15.0 m: 152.1 min.
18.0 m:  85.0 min.  21.0 m:  59.3 min.  24.0 m:  42.1 min.  27.0 m:  30.9 min.
30.0 m:  23.8 min.  33.0 m:  18.2 min.  36.0 m:  14.9 min.  39.0 m:  12.7 min.
42.0 m:  11.1 min.  45.0 m:   9.5 min.  48.0 m:   8.1 min.  51.0 m:   7.1 min.
54.0 m:   6.4 min.  57.0 m:   5.8 min.  60.0 m:   5.3 min.  63.0 m:   4.9 min.
 what next?
```

14-2: NDL table for EAN 28

These NDLs are displayed from 6 to 63 m, regardless their respective MOD! The figures see the first decimal as a result of the calculation. A living, printed dive table will definitively show rounded down numbers, normally not just to the next lower integer, but to somewhat smaller numbers, due to intrinsic, hidden, safety factors.

With an increasing pO_2 the NDLs sky-rocket: if the value is too big, you will see just: **********.

(Sources:)
A set of NOAA Nitrox / EANx tables form 2017 you could find for e.g. there:
https://www.divetable.info/workshop/194_EAN.pdf

And a compilation of all topical (2016) USN tables is there:
https://www.divetable.info/workshop/USN_Rev7_Tables.pdf

The next caveat yields for ALL digital-generated outputs, being from a desktop deco-software or on-line from a diver-carried computer: due to, in general possible, smaller time-steps in comparison to a table, there will be deviations (*). This is clearly antedated, for eg. with a different, more conservative, set of the coeffcients. Thus Buehlmann offered in his last book 3 sets: the ZH-L 16 A, B & C sets (Source: [65], p. 158)!

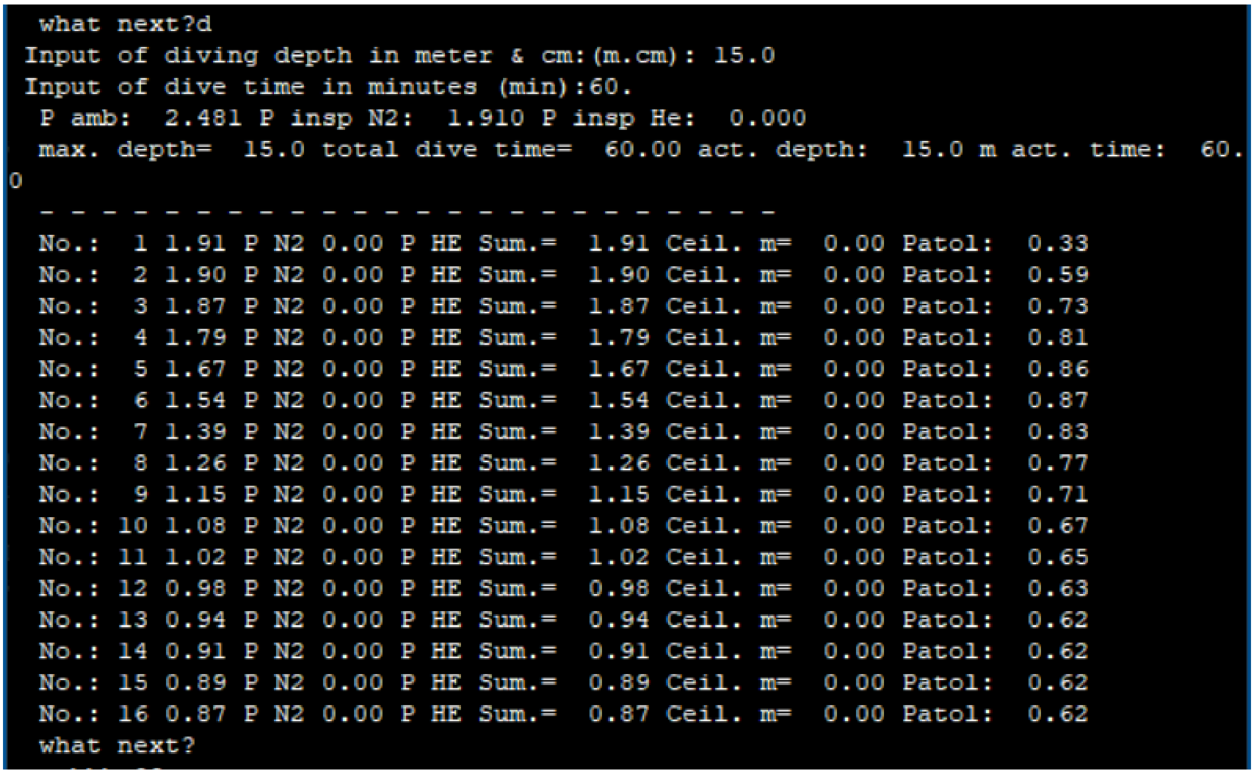
And, as well: in the standard EAN manuals of the various training agencies you will find the NOAA %CNS tables cited, with a pO_2 in Bar. Please note, that all of the original works are using ata / atm!
(Sources: Hamilton, R.W., Kenyon, D.J., Peterson, R. E., Butler, G.J., Beers, D.M., 1988 May, Repex: Development of repetitive excursions, surfacing techniques, and oxygen procedures for habitat diving, NURP Technical Report 88-1A, Rockwell M.D., U.S. DoD;
The NOAA manuals: [194], [149], [48])

(*) and with „deviations“ is very clearly not meant, what Thalmann called „executive editing“ resp. the typos he found in 1983: Ed Thalmann, NEDU Report 13-83. And, another one: „The final tables contain a variety of executive edits to algorithmically-computed entries“ (NEDU TR 09-05 / TA-8-20, p. 1 & 5).

15 Simulation of a rec. NDL dive

Next easy one is a simulation of a recreational dive on air within a so-called NDL: we want to stay for 1 h in 15 m:

d", "15.0", "60", then via "a" directly to the surface, because the allowed ceiling is 0:



```
 what next?d
Input of diving depth in meter & cm:(m.cm): 15.0
Input of dive time in minutes (min):60.
 P amb:  2.481 P insp N2:  1.910 P insp He:  0.000
 max. depth=  15.0 total dive time=  60.00 act. depth:  15.0 m act. time:  60.
0
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 No.:  1 1.91 P N2 0.00 P HE Sum.=  1.91 Ceil. m=  0.00 Patol:  0.33
 No.:  2 1.90 P N2 0.00 P HE Sum.=  1.90 Ceil. m=  0.00 Patol:  0.59
 No.:  3 1.87 P N2 0.00 P HE Sum.=  1.87 Ceil. m=  0.00 Patol:  0.73
 No.:  4 1.79 P N2 0.00 P HE Sum.=  1.79 Ceil. m=  0.00 Patol:  0.81
 No.:  5 1.67 P N2 0.00 P HE Sum.=  1.67 Ceil. m=  0.00 Patol:  0.86
 No.:  6 1.54 P N2 0.00 P HE Sum.=  1.54 Ceil. m=  0.00 Patol:  0.87
 No.:  7 1.39 P N2 0.00 P HE Sum.=  1.39 Ceil. m=  0.00 Patol:  0.83
 No.:  8 1.26 P N2 0.00 P HE Sum.=  1.26 Ceil. m=  0.00 Patol:  0.77
 No.:  9 1.15 P N2 0.00 P HE Sum.=  1.15 Ceil. m=  0.00 Patol:  0.71
 No.: 10 1.08 P N2 0.00 P HE Sum.=  1.08 Ceil. m=  0.00 Patol:  0.67
 No.: 11 1.02 P N2 0.00 P HE Sum.=  1.02 Ceil. m=  0.00 Patol:  0.65
 No.: 12 0.98 P N2 0.00 P HE Sum.=  0.98 Ceil. m=  0.00 Patol:  0.63
 No.: 13 0.94 P N2 0.00 P HE Sum.=  0.94 Ceil. m=  0.00 Patol:  0.62
 No.: 14 0.91 P N2 0.00 P HE Sum.=  0.91 Ceil. m=  0.00 Patol:  0.62
 No.: 15 0.89 P N2 0.00 P HE Sum.=  0.89 Ceil. m=  0.00 Patol:  0.62
 No.: 16 0.87 P N2 0.00 P HE Sum.=  0.87 Ceil. m=  0.00 Patol:  0.62
 what next?
```

15-1: "NDL"-simulation

You see the dive parameters and per compartment, each on one line from 1 to 16.
The calculated inertgas pressures, the sum, which is the same for air/EANX, the ceiling (i.e. the allowed minimal depth for an ascent) and the according tolerated ambient pressures. Only if this value exceeds 1.0 starts a decompression obligation.

E.g.: a tolerated P_{ambient} = 1.3 would translate to a ceiling of min. 3 m, hence the deco stop depth.

Remark: from time to time you will find in this documentation the notion „NDL“ embellished with quotation marks „“. This is just to remind you that a real, scientific viable NDL is not from this planet. Later on in this manual we will cover the P(DCS) calculations in detail. For now, only one hint to convince you: if you look at the „NDL“s of the various training agencies, you will find really wild deviations. An overview of the usual NDL sets with a couple of examples you may find there:

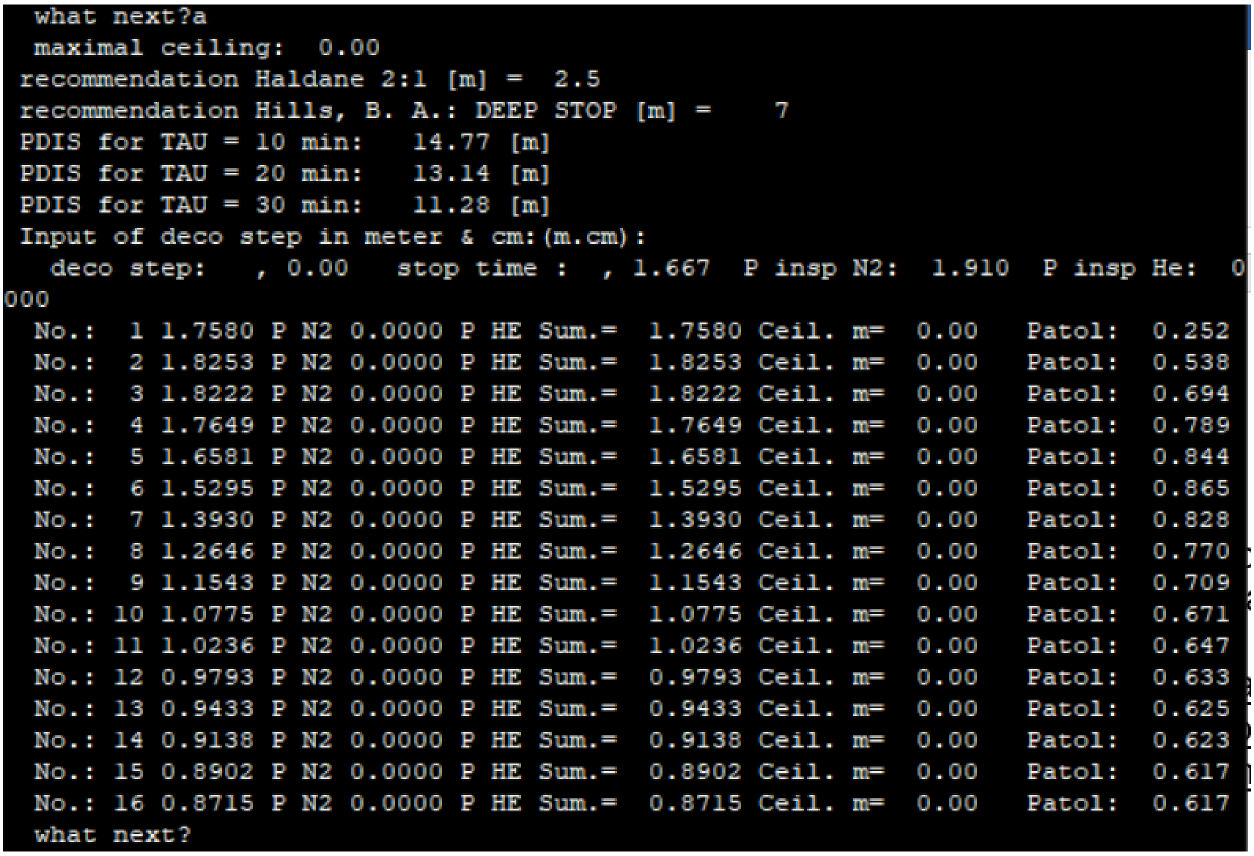
https://www.divetable.info/dekotg_e.htm

Especially after the SI and a repetitive dive the variations in the „NDL“ become bigger and bigger between the training-paradigms, until they go nuts for the 3rd or 4th dive ….

Thus, diving a „NDL“ means that you did accept tacitly a risk of contracting a decompression sickness (P(DCS)) which may be small, but definitively different from 0! This is an intrinsic risk for all rec dives, where you do not want to make a stop.

As a matter of course, scout’s honor, DIVE can assist you with the hard facts on these topics: just simulate a couple of your favorite „NDL“-profiles and have a look at the impressive P(DCS) figures.

With „a“ we start the ascent, if we key in „0.0“ then our little cyber-diver jumps directly to the surface, with the ascent rate defaulting to 9.0 m / min:

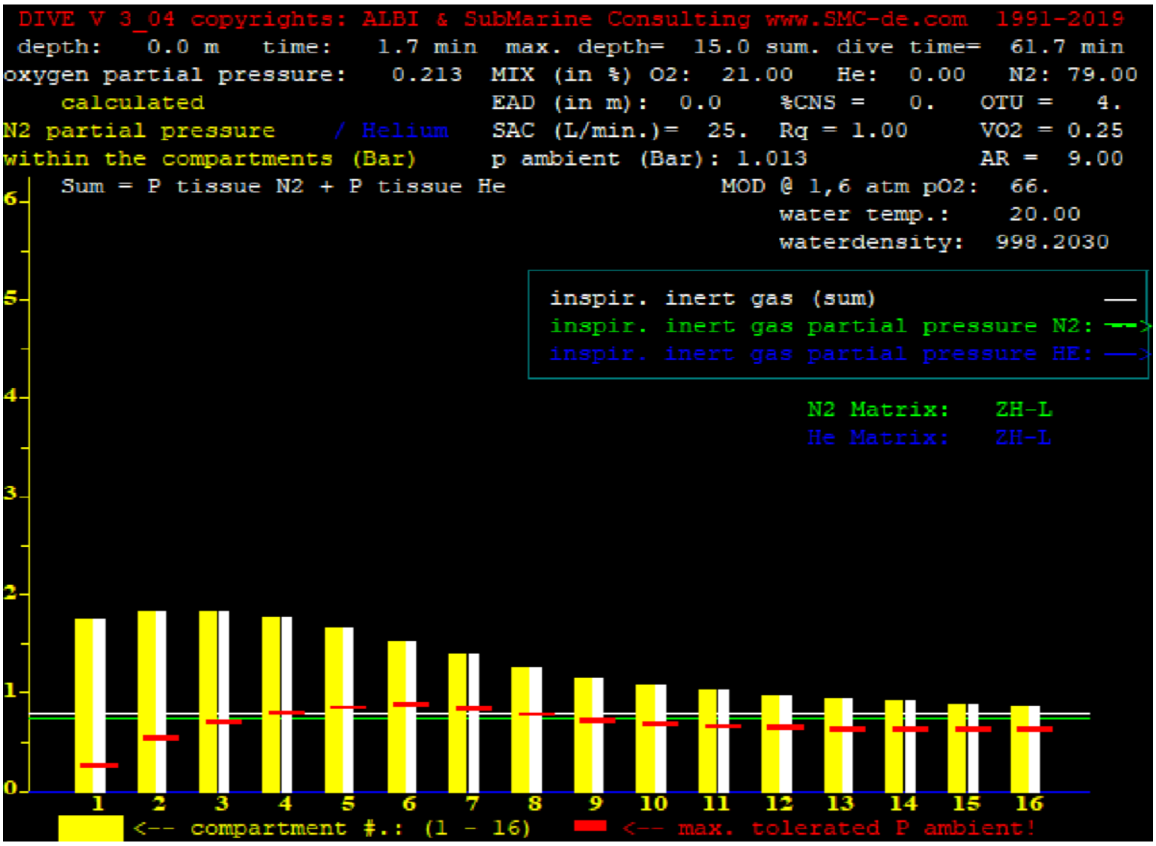


```
  what next?a
  maximal ceiling:  0.00
 recommendation Haldane 2:1 [m] =  2.5
 recommendation Hills, B. A.: DEEP STOP [m] =    7
 PDIS for TAU = 10 min:   14.77 [m]
 PDIS for TAU = 20 min:   13.14 [m]
 PDIS for TAU = 30 min:   11.28 [m]
 Input of deco step in meter & cm:(m.cm):
   deco step:   , 0.00   stop time :  , 1.667  P insp N2:  1.910  P insp He:  0
000
  No.:  1 1.7580 P N2 0.0000 P HE Sum.=  1.7580 Ceil. m=  0.00   Patol:  0.252
  No.:  2 1.8253 P N2 0.0000 P HE Sum.=  1.8253 Ceil. m=  0.00   Patol:  0.538
  No.:  3 1.8222 P N2 0.0000 P HE Sum.=  1.8222 Ceil. m=  0.00   Patol:  0.694
  No.:  4 1.7649 P N2 0.0000 P HE Sum.=  1.7649 Ceil. m=  0.00   Patol:  0.789
  No.:  5 1.6581 P N2 0.0000 P HE Sum.=  1.6581 Ceil. m=  0.00   Patol:  0.844
  No.:  6 1.5295 P N2 0.0000 P HE Sum.=  1.5295 Ceil. m=  0.00   Patol:  0.865
  No.:  7 1.3930 P N2 0.0000 P HE Sum.=  1.3930 Ceil. m=  0.00   Patol:  0.828
  No.:  8 1.2646 P N2 0.0000 P HE Sum.=  1.2646 Ceil. m=  0.00   Patol:  0.770
  No.:  9 1.1543 P N2 0.0000 P HE Sum.=  1.1543 Ceil. m=  0.00   Patol:  0.709
  No.: 10 1.0775 P N2 0.0000 P HE Sum.=  1.0775 Ceil. m=  0.00   Patol:  0.671
  No.: 11 1.0236 P N2 0.0000 P HE Sum.=  1.0236 Ceil. m=  0.00   Patol:  0.647
  No.: 12 0.9793 P N2 0.0000 P HE Sum.=  0.9793 Ceil. m=  0.00   Patol:  0.633
  No.: 13 0.9433 P N2 0.0000 P HE Sum.=  0.9433 Ceil. m=  0.00   Patol:  0.625
  No.: 14 0.9138 P N2 0.0000 P HE Sum.=  0.9138 Ceil. m=  0.00   Patol:  0.623
  No.: 15 0.8902 P N2 0.0000 P HE Sum.=  0.8902 Ceil. m=  0.00   Patol:  0.617
  No.: 16 0.8715 P N2 0.0000 P HE Sum.=  0.8715 Ceil. m=  0.00   Patol:  0.617
  what next?
```

15-2: ascent after „NDL“

We see recommendations for various „deep stops“, which we will cover in-depth later on with a TEC dive. The designated ceiling of 0.0 is our wish, beeing a „NDL“-dive. As an additional excercise you run this again, but keying in „4.5“ to reach a lower depth for a safety stop.

If you got already bored with all these figures from the calculated inertgas saturations from the 16 compartments, just hit „p“ to plot everything: all these numbers have been converted to boxes, yellow in the case of nitrogen, blue for helium, not for this particular dive. The dive parameters you see in the first couple of lines on top of the displayed graphics:



```
 DIVE V 3_04 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2019
 depth:   0.0 m   time:   1.7 min  max. depth=  15.0 sum. dive time=  61.7 min
oxygen partial pressure:   0.213  MIX (in %) O2:  21.00   He:  0.00   N2: 79.00
    calculated                    EAD (in m):  0.0    %CNS =   0.   OTU =   4.
N2 partial pressure    / Helium   SAC (L/min.)=  25.  Rq = 1.00     VO2 = 0.25
within the compartments (Bar)     p ambient (Bar): 1.013            AR =  9.00
    Sum = P tissue N2 + P tissue He              MOD @ 1,6 atm pO2:  66.
                                                     water temp.:    20.00
                                                     waterdensity:  998.2030

                                    inspir. inert gas (sum)
                                    inspir. inert gas partial pressure N2:
                                    inspir. inert gas partial pressure HE:

                                                     N2 Matrix:    ZH-L
                                                     He Matrix:    ZH-L

    <-- compartment #.: (1 - 16)        <-- max. tolerated P ambient!
```

15-3: „p“ after hitting the surface

The size of the colored boxes is proportional to the absolute inertgas partial pressure in the compartment (left side: y-axis), the identifying no. you see on the x-axis (1 → 16). You see immediately what is going on in a compartment: still saturation, if box is below the horizontal colored lines, or, as in this case above, where all the boxes are above the green (N_2) and white line (sum): already de-saturation / off-gassing. The little red lines are coming directly from the default ZH-L 16 and are indicating the tolerated ambient pressure: if this greater than the ambient pressure, it indicates a decompression obligation! Hitting „Return“ you leave this picture.

You could do the next excercise, if you want to check the next fairy tale of a couple of „rec“ training agencies, that is: after 6 or 12 h SI the diver is „clean“. So we do, say, 2 of your favorite NDL-profiles at your favorite house-reef and then, say over night, we check your N_2-status, clearly indicating, that your are NOT!

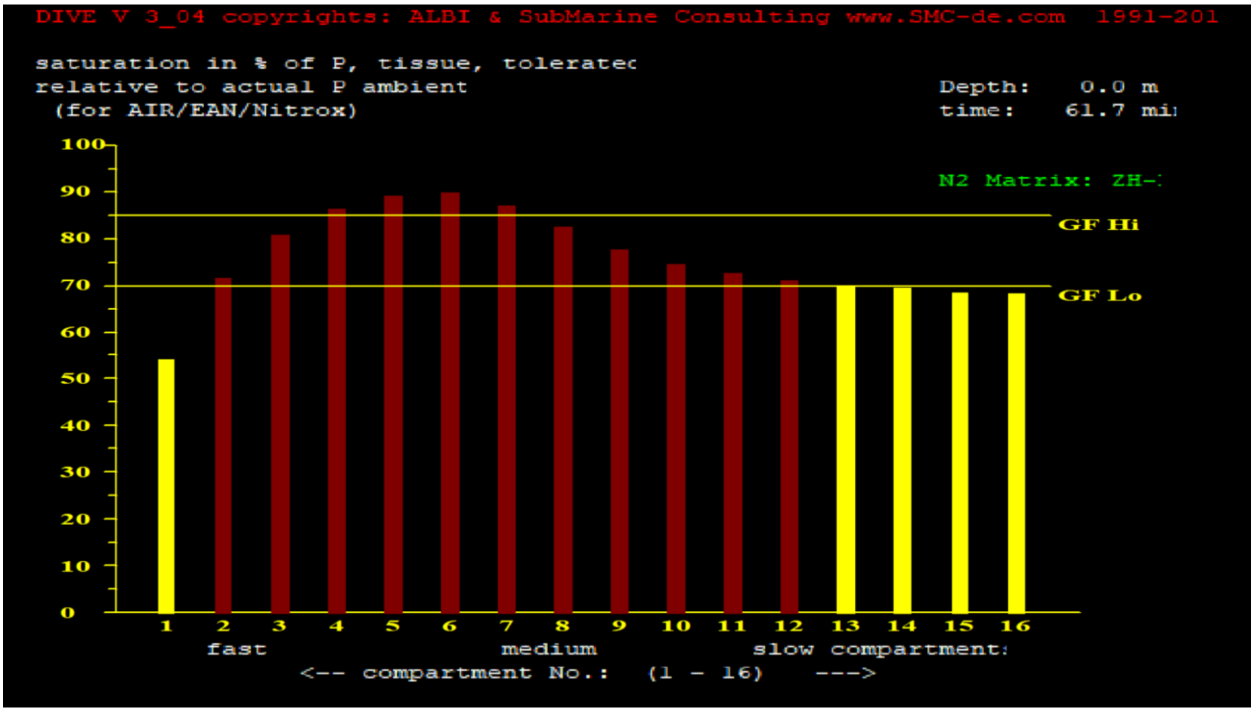
So, the inputs would be:
1st dive: „d“ „20.0“ „45.“ „a“ „0.0“
Surface Interval (SI), i.e. de-saturation via „e“ at depth „0.0“ that is, when DIVE asks for a „deco pause“, we key in: „120“ as SI of 2 h between 1st. and 2nd. dive
2nd dive: „d“ „15.0“ „35.“ „a“ „0.0“
SI: during over-night, say 8 h = 480 min: „e“ „0.0“ „480.“
Now, with „z“ or „p“ you see clearly, that there is really a substantial inertgas saturation in the slow compartments, which only a good computer will take into account for the next dive, and no standard table. Ok, let‘s say you stay another 4 h dry, to make complete the SI = 12 h:
SI: „e“ „0.0“ „240.“:

Wow! Still after 12 h, your slowest compartments are super-saturated, and this, after only 2 trivial dives… You do not want to tell me, that you, staying on an expensive live-aboard, diving your precious 5 day-holiday, with the non-limit diving safari already payed, would dive like that??? No, you won't … 😊

N.B: attention!

Remark concerning the box/bar diagrams: if you want to compare DIVE with other products, say the SDM, the Suunto® Dive Manager or SmartTRAK from UWATEC® etc. …:
with „p“ or „z“ DIVE displays all the values as absolute, in Bar. The others, normally not so: thus you can not compare directly. If you want to see the values, relative to any allowed super-saturation, key in „%p“ (as percent plot), which gives exactly this, especially in relation to any gradient factors.

To put these „NDL“ into perspective of how DAN (= „Divers Alert Network“) sees this, just key in this „%p“ after you simulated the above 15m/60min NDL-dive:



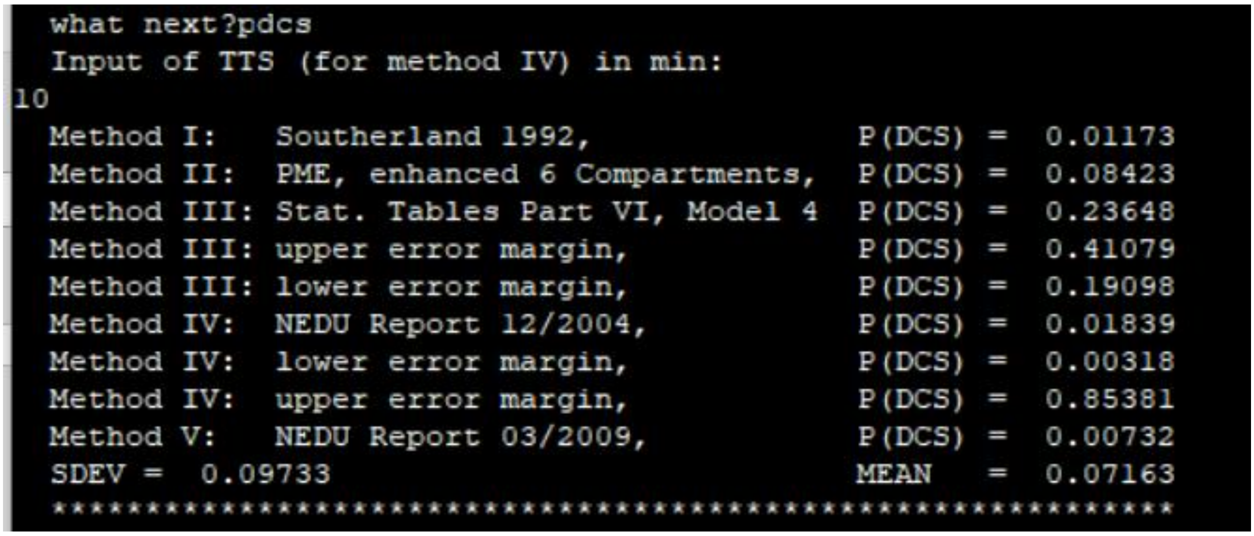
15-4: „%p“ after hitting the surface

Want another little excercise with „NDLs“?
Yep, no problem: 30 m / 17 min is in the widespread european DECO 2000 table from my late friend Dr. Max Hahn (The source for Maxe's oevre, the DECO92 and its siblings, the Deco 92 Version 2 and the Deco 2000 is this: [43]), considered as „NDL“; the rest of the training agencies will still allow more! 20 min from NAUI, PADI, SSI; even the NAUI RGBM allows for 20 min. Nonetheless we are going to make a stop at 6 m for 5 min, checking afterwards the P(DCS), the statistical probability of contracting a decompressionsickness and as well the DAN DRA (Decompression Risk Analysis):

„d“	→	30.	17.
„PDCS“	→	10.	(the TTS for method IV: ascent- + stop times)
„a“	→	6.	
„d“	→	6.	5 (the stop)
„a“	→	0.	Final ascent to the surface

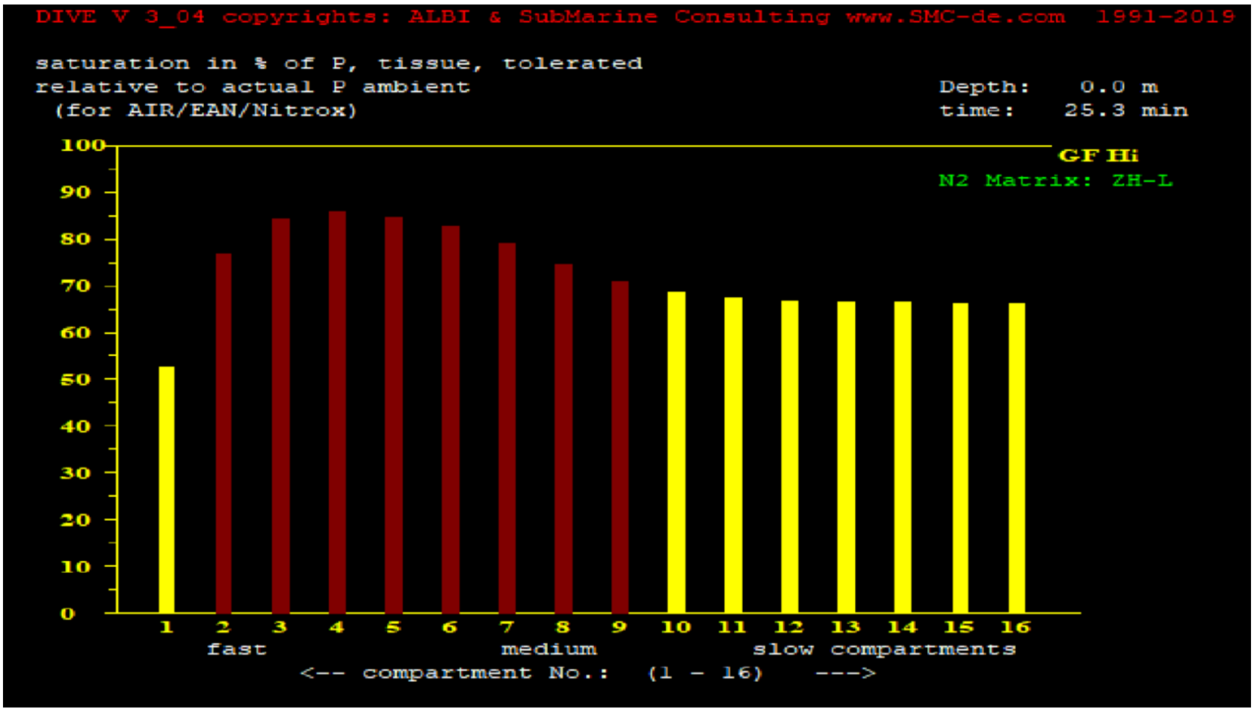
„%P“

and recieve thus our basis for discussion:



```
 what next?pdcs
 Input of TTS (for method IV) in min:
10
 Method I:   Southerland 1992,                  P(DCS) =  0.01173
 Method II:  PME, enhanced 6 Compartments,      P(DCS) =  0.08423
 Method III: Stat. Tables Part VI, Model 4      P(DCS) =  0.23648
 Method III: upper error margin,                P(DCS) =  0.41079
 Method III: lower error margin,                P(DCS) =  0.19098
 Method IV:  NEDU Report 12/2004,               P(DCS) =  0.01839
 Method IV:  lower error margin,                P(DCS) =  0.00318
 Method IV:  upper error margin,                P(DCS) =  0.85381
 Method V:   NEDU Report 03/2009,               P(DCS) =  0.00732
 SDEV =   0.09733                               MEAN   =  0.07163
 ************************************************************
```

15-5: P(DCS) for the "NDL" dive (30 m, 17 min.)



15-6: DAN Decompression Risk Analysis (DRA) for this "NDL"-dive, at surfacing

1) For this „NDL“-dive is the P(DCS) not negligible: we have various indications ranging from 0.7 up to nearly 2% (method IV, ignoring method III for the moment). This is not menacing much, but a very much more differentiated statement than just „NDL“

2) Still, after this „safety stop“ (6 m, 5 min) we have a couple of fast compartments which DAN would consider as critically supersaturated (the red boxes)

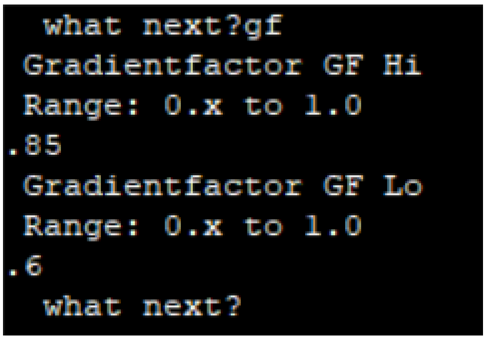
Thus, the simple question of an advanced diver would be: „ … uuups: 2%! That would imply that out of my, maybe 200 similar dives, ca. 4 must have had DCS-problems???“ Yep: exactly! BUT:

1) DCS problems or a substantial P(DCS) is not automatically equivalent with a stay in the recompression chamber! There is: a wealth of „sub-clinical“ DCS, „marginal symptoms“, „silent bubbles“ and so on.

2) The above mentioned tables, and, as well the simulation you just did with DIVE are assuming a box profile with a very high inertgas-dose, i.e.: that you did stay <u>all of the 17 min at exactly 30 m</u>! I'll bet you anything, you normally don't! That is, your real inertgas-dose, and thus as well, your real P(DCS) is by far lower … As well ALL the tables and a lot of desktop deco-softwares are asuming another safety-factor in favor of you: it is the instantaneous descent, that is: going down from 0 to the bottom-depth with infinite speed … and thus, your little electronic gadget is displaying a lot of remaining „ND-time“ during ascent.

3) But, after all, with DIVE you have a real chance of keying in a more realistic profile …

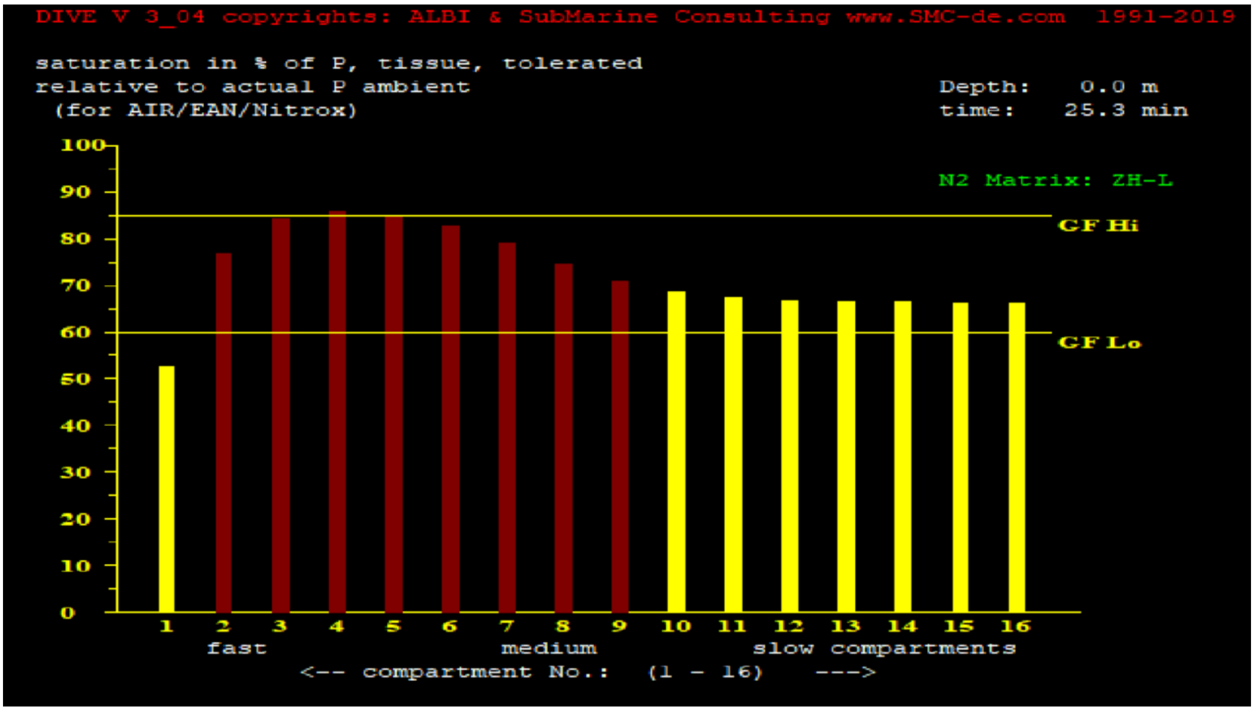
4) With enough breathing gas and thermal protection it is no problem to reach these 17 or 20 min, or even exceed them. So with a lot of workload, physical & mental excertion, drift, coldness etc. it does make sense to transform this „NDL“-dive into a real deco dive. This could be done easily with the so-called „Gradient factors“ (GF). If you key them in, for e.g.:
„gf“ „.85“ „.6“ :



```
  what next?gf
 Gradientfactor GF Hi
 Range: 0.x to 1.0
.85
 Gradientfactor GF Lo
 Range: 0.x to 1.0
.6
  what next?
```

15-7: Input of Gradient Factors

Then the „%p“ -plot will help you again:

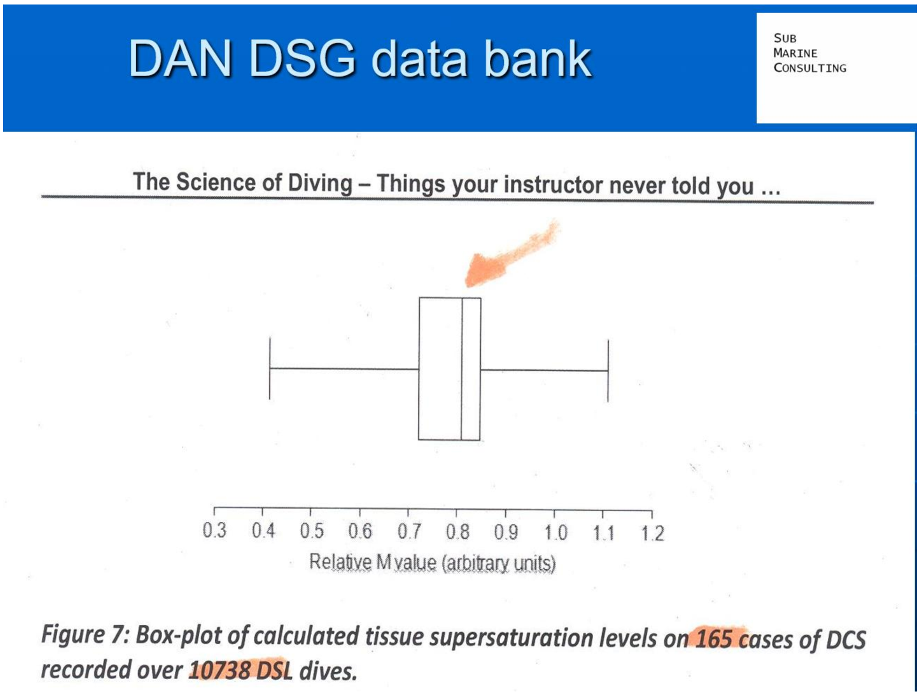


15-8: %p with Gradient Factors High and Low (yellow horizontal lines)

So far, so good: all these diving tables and your dive computer gave you a „green light“, i.e.: „NDL“. If one of the red boxes hits the 100% margin, a decompression obligation begins. The compartment making it, i.e.: the one who wins the race to the 100 %line, will be the „lead compartment“, or leading compartment. It tells his other colleague-compartments, how long they have to stay there, before they are allowed to move one storey up to the next deco stop.

In the picture above it will be comp. #4. And as you may well imagine, the more you move up, the more the lead compartment will move to the right, to higher numbers. But this in turn tells you that the hang times are increasing.

The color scheme and everything else will be covered in the „%P“-chapter. So far, so good again. But now comes the real bad news! Despite the „green lights“ your are prone getting a DCS hit. This is one of the results from DAN, a statistical analysis from their collection of uploaded real dive profiles into their DSG data bank (Diver Safety Guardian):



DAN DSG data bank

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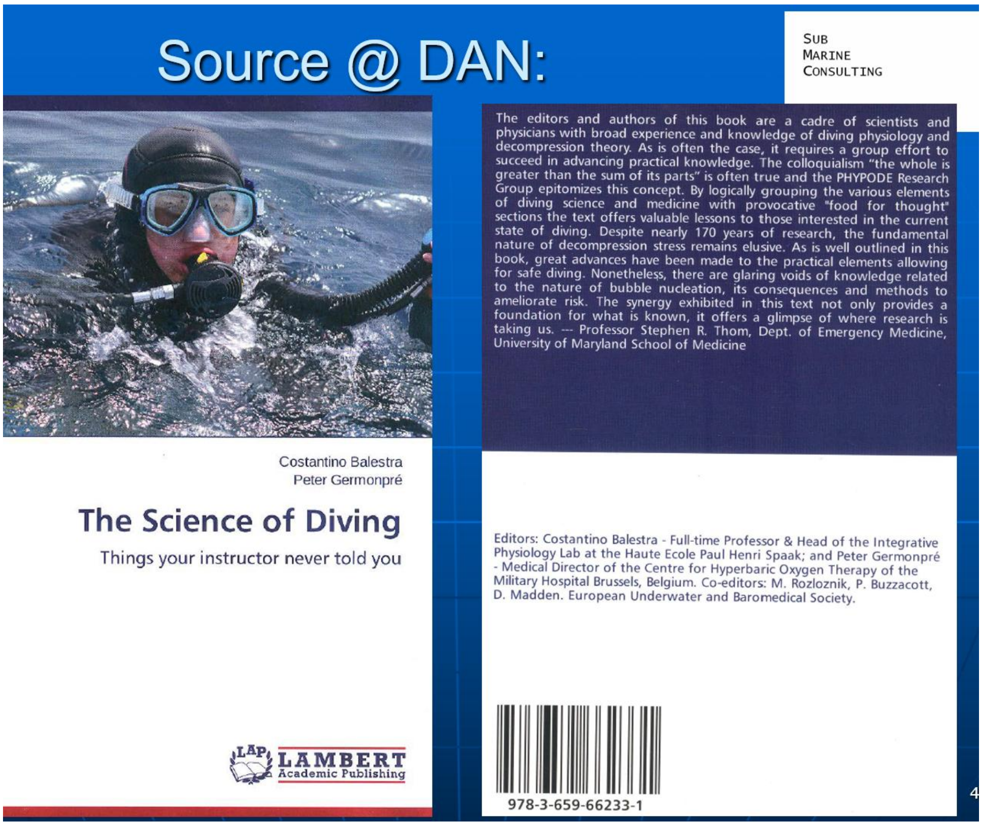
The Science of Diving – Things your instructor never told you …

Figure 7: Box-plot of calculated tissue supersaturation levels on 165 cases of DCS recorded over 10738 DSL dives.

15-9: result from the DAN DSG

Basically it tells us, that despite the calculated / simulated inertgas partialpressures in the compartments staying well below 100 %, not even eceeding 80 % significantly, the DCS rate out of these 10,738 dives was greater than 1.5 %!

The source of all this wisdom, and even more is this one:



Source @ DAN:

SUB
MARINE
CONSULTING

Costantino Balestra
Peter Germonpré

The Science of Diving

Things your instructor never told you

LAP LAMBERT Academic Publishing

The editors and authors of this book are a cadre of scientists and physicians with broad experience and knowledge of diving physiology and decompression theory. As is often the case, it requires a group effort to succeed in advancing practical knowledge. The colloquialism "the whole is greater than the sum of its parts" is often true and the PHYPODE Research Group epitomizes this concept. By logically grouping the various elements of diving science and medicine with provocative "food for thought" sections the text offers valuable lessons to those interested in the current state of diving. Despite nearly 170 years of research, the fundamental nature of decompression stress remains elusive. As is well outlined in this book, great advances have been made to the practical elements allowing for safe diving. Nonetheless, there are glaring voids of knowledge related to the nature of bubble nucleation, its consequences and methods to ameliorate risk. The synergy exhibited in this text not only provides a foundation for what is known, it offers a glimpse of where research is taking us. --- Professor Stephen R. Thom, Dept. of Emergency Medicine, University of Maryland School of Medicine

Editors: Costantino Balestra - Full-time Professor & Head of the Integrative Physiology Lab at the Haute Ecole Paul Henri Spaak; and Peter Germonpré - Medical Director of the Centre for Hyperbaric Oxygen Therapy of the Military Hospital Brussels, Belgium. Co-editors: M. Rozloznik, P. Buzzacott, D. Madden. European Underwater and Baromedical Society.

978-3-659-66233-1

15-10: the DAN source

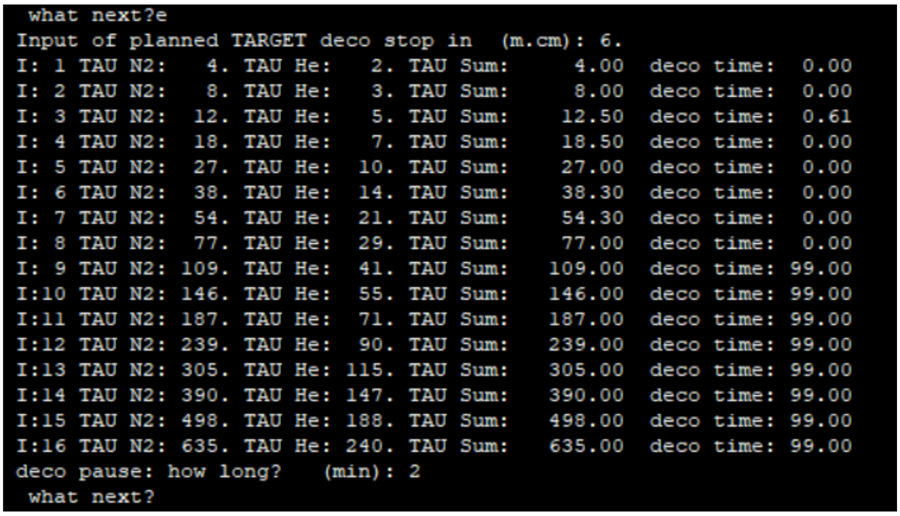
If you are interested and want to go in-depth: the real good news is, that a diver-friendly version (no charts, no formula, no doctors-lingo …) of the above source you will find in our „Manual-4-free“ site: https://www.divetable.eu/221_main.pdf

As well there is a little bit more scientific stuff for P(DCS) @ single 30 m dive on air:
On the statistical probability of contracting a decompression sickness
 after a single scuba dive on air within a no-decompression-limit
DOI: 10.13140/RG.2.2.17249.74084

16 Another simulation: a deco dive

Let’s take the parameters from the „Quick Start“ dive: 42 m, 25 min: we will exploit the deep stop recommendations and then going up, slowly, slowly to make our hang-time at 9, 6, & 3 m always with:

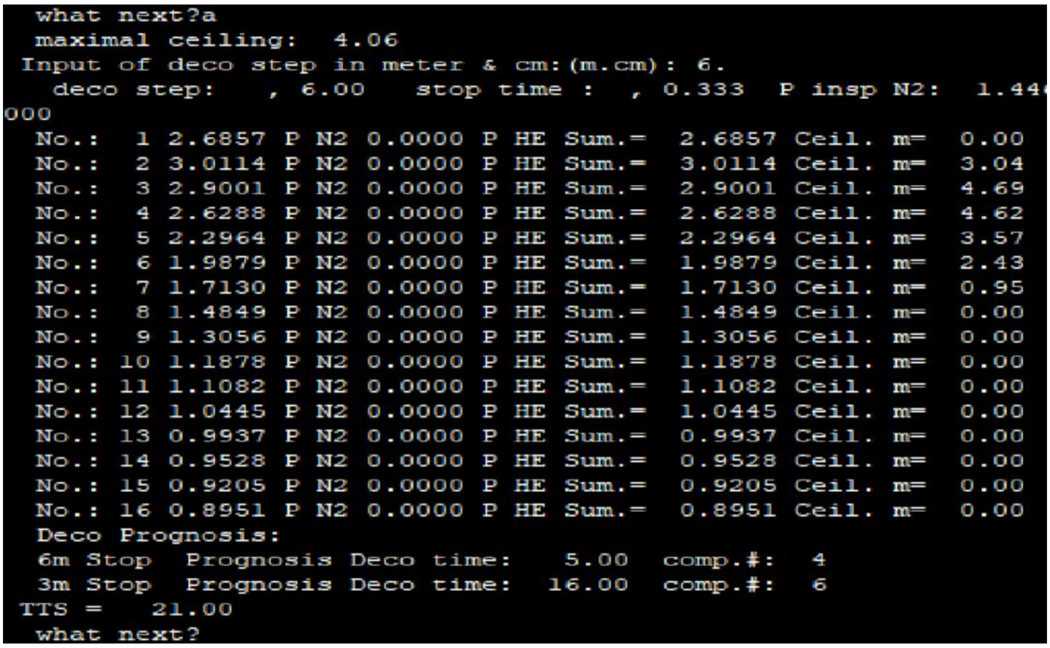
"a" -> desired depth, for e.g. 9 m (always lower than the topical ceiling), and then:
"e" -> target depth of the next stop, here: 6 m



```
 what next?e
Input of planned TARGET deco stop in  (m.cm): 6.
I: 1 TAU N2:   4. TAU He:   2. TAU Sum:    4.00  deco time:  0.00
I: 2 TAU N2:   8. TAU He:   3. TAU Sum:    8.00  deco time:  0.00
I: 3 TAU N2:  12. TAU He:   5. TAU Sum:   12.50  deco time:  0.61
I: 4 TAU N2:  18. TAU He:   7. TAU Sum:   18.50  deco time:  0.00
I: 5 TAU N2:  27. TAU He:  10. TAU Sum:   27.00  deco time:  0.00
I: 6 TAU N2:  38. TAU He:  14. TAU Sum:   38.30  deco time:  0.00
I: 7 TAU N2:  54. TAU He:  21. TAU Sum:   54.30  deco time:  0.00
I: 8 TAU N2:  77. TAU He:  29. TAU Sum:   77.00  deco time:  0.00
I: 9 TAU N2: 109. TAU He:  41. TAU Sum:  109.00  deco time: 99.00
I:10 TAU N2: 146. TAU He:  55. TAU Sum:  146.00  deco time: 99.00
I:11 TAU N2: 187. TAU He:  71. TAU Sum:  187.00  deco time: 99.00
I:12 TAU N2: 239. TAU He:  90. TAU Sum:  239.00  deco time: 99.00
I:13 TAU N2: 305. TAU He: 115. TAU Sum:  305.00  deco time: 99.00
I:14 TAU N2: 390. TAU He: 147. TAU Sum:  390.00  deco time: 99.00
I:15 TAU N2: 498. TAU He: 188. TAU Sum:  498.00  deco time: 99.00
I:16 TAU N2: 635. TAU He: 240. TAU Sum:  635.00  deco time: 99.00
deco pause: how long?   (min): 2
 what next?
```

16-1: desaturation and lead compartment at the 9 m stop

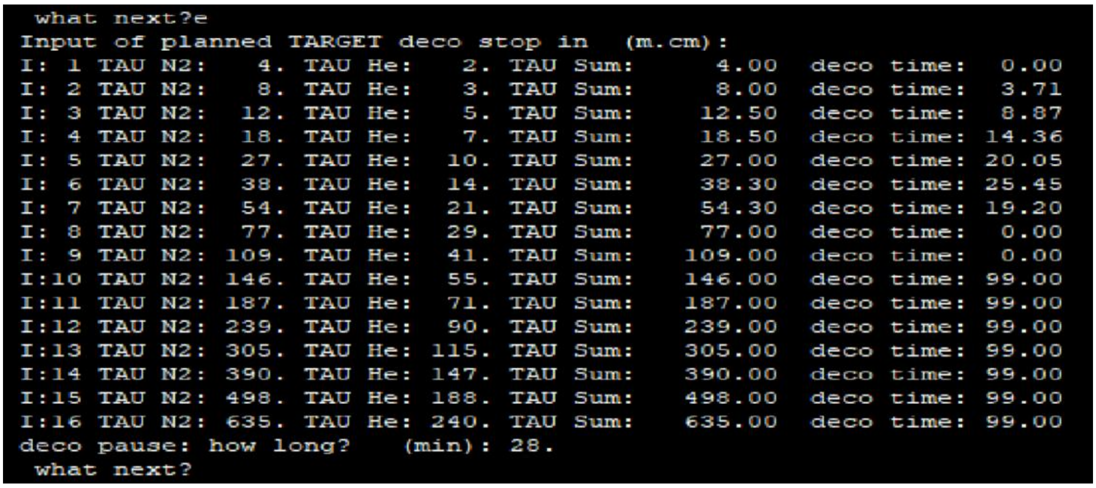
You will see the leading compartment, here it is #3, this one is responsible for the hang-time of 0.61. A table or a dive computer would display here 1, or maybe, 2 min.
Thus we keyed in the „2“; now:
„a“ „6.0“, resulting in:



```
  what next?a
  maximal ceiling:   4.06
 Input of deco step in meter & cm:(m.cm): 6.
   deco step:    , 6.00    stop time :   , 0.333   P insp N2:   1.44
000
  No.:   1 2.6857 P N2 0.0000 P HE Sum.=  2.6857 Ceil. m=  0.00
  No.:   2 3.0114 P N2 0.0000 P HE Sum.=  3.0114 Ceil. m=  3.04
  No.:   3 2.9001 P N2 0.0000 P HE Sum.=  2.9001 Ceil. m=  4.69
  No.:   4 2.6288 P N2 0.0000 P HE Sum.=  2.6288 Ceil. m=  4.62
  No.:   5 2.2964 P N2 0.0000 P HE Sum.=  2.2964 Ceil. m=  3.57
  No.:   6 1.9879 P N2 0.0000 P HE Sum.=  1.9879 Ceil. m=  2.43
  No.:   7 1.7130 P N2 0.0000 P HE Sum.=  1.7130 Ceil. m=  0.95
  No.:   8 1.4849 P N2 0.0000 P HE Sum.=  1.4849 Ceil. m=  0.00
  No.:   9 1.3056 P N2 0.0000 P HE Sum.=  1.3056 Ceil. m=  0.00
  No.:  10 1.1878 P N2 0.0000 P HE Sum.=  1.1878 Ceil. m=  0.00
  No.:  11 1.1082 P N2 0.0000 P HE Sum.=  1.1082 Ceil. m=  0.00
  No.:  12 1.0445 P N2 0.0000 P HE Sum.=  1.0445 Ceil. m=  0.00
  No.:  13 0.9937 P N2 0.0000 P HE Sum.=  0.9937 Ceil. m=  0.00
  No.:  14 0.9528 P N2 0.0000 P HE Sum.=  0.9528 Ceil. m=  0.00
  No.:  15 0.9205 P N2 0.0000 P HE Sum.=  0.9205 Ceil. m=  0.00
  No.:  16 0.8951 P N2 0.0000 P HE Sum.=  0.8951 Ceil. m=  0.00
  Deco Prognosis:
  6m Stop   Prognosis Deco time:    5.00   comp.#:   4
  3m Stop   Prognosis Deco time:   16.00   comp.#:   6
 TTS =    21.00
  what next?
```

16-2: prognosis at the 6 m stop

Now, again the game with ascent („a") and de-saturation („e"), but since there are a lot of waves or mindless jerks with their jet-skies, rubber ducks or, what ever: we decide not to go to 3 m, but try to make the complete hang-time at 6 m, due to our security concerns, that is: „e" „0.0":

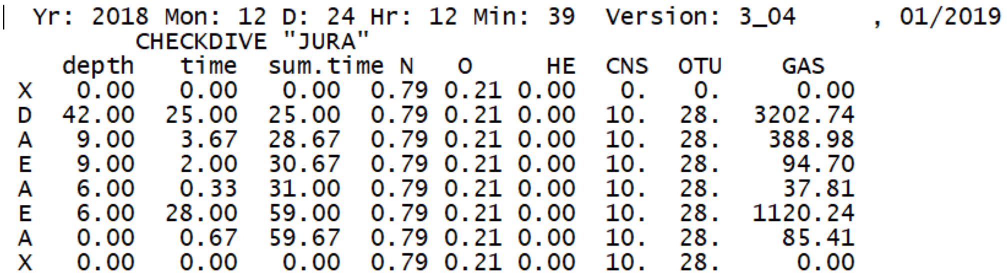


```
  what next?e
 Input of planned TARGET deco stop in   (m.cm):
 I:  1 TAU N2:    4. TAU He:    2. TAU Sum:      4.00  deco time:  0.00
 I:  2 TAU N2:    8. TAU He:    3. TAU Sum:      8.00  deco time:  3.71
 I:  3 TAU N2:   12. TAU He:    5. TAU Sum:     12.50  deco time:  8.87
 I:  4 TAU N2:   18. TAU He:    7. TAU Sum:     18.50  deco time: 14.36
 I:  5 TAU N2:   27. TAU He:   10. TAU Sum:     27.00  deco time: 20.05
 I:  6 TAU N2:   38. TAU He:   14. TAU Sum:     38.30  deco time: 25.45
 I:  7 TAU N2:   54. TAU He:   21. TAU Sum:     54.30  deco time: 19.20
 I:  8 TAU N2:   77. TAU He:   29. TAU Sum:     77.00  deco time:  0.00
 I:  9 TAU N2:  109. TAU He:   41. TAU Sum:    109.00  deco time:  0.00
 I:10 TAU N2:  146. TAU He:   55. TAU Sum:    146.00  deco time: 99.00
 I:11 TAU N2:  187. TAU He:   71. TAU Sum:    187.00  deco time: 99.00
 I:12 TAU N2:  239. TAU He:   90. TAU Sum:    239.00  deco time: 99.00
 I:13 TAU N2:  305. TAU He:  115. TAU Sum:    305.00  deco time: 99.00
 I:14 TAU N2:  390. TAU He:  147. TAU Sum:    390.00  deco time: 99.00
 I:15 TAU N2:  498. TAU He:  188. TAU Sum:    498.00  deco time: 99.00
 I:16 TAU N2:  635. TAU He:  240. TAU Sum:    635.00  deco time: 99.00
 deco pause: how long?    (min): 28.
  what next?
```

16-3: leading compartment and prognosis for direct ascent from 6 to 0 m

The leading compartment has changed from #3 to #6, giving 26 min, instead of the 16 min at 3 m: this is the trade-in for a reduced off-gasing gradient at the greater depth.

If DIVE finds the C:\DIVE\PROT directory, it will write there the accompanying run-time as a protocol file, the PROTOCOL.TXT:



```
| Yr: 2018 Mon: 12 D: 24 Hr: 12 Min: 39  Version: 3_04     , 01/2019
          CHECKDIVE "JURA"
    depth    time   sum.time N    O     HE   CNS   OTU    GAS
 X   0.00    0.00    0.00  0.79 0.21 0.00   0.    0.      0.00
 D  42.00   25.00   25.00  0.79 0.21 0.00  10.   28.   3202.74
 A   9.00    3.67   28.67  0.79 0.21 0.00  10.   28.    388.98
 E   9.00    2.00   30.67  0.79 0.21 0.00  10.   28.     94.70
 A   6.00    0.33   31.00  0.79 0.21 0.00  10.   28.     37.81
 E   6.00   28.00   59.00  0.79 0.21 0.00  10.   28.   1120.24
 A   0.00    0.67   59.67  0.79 0.21 0.00  10.   28.     85.41
 X   0.00    0.00    0.00  0.79 0.21 0.00  10.   28.      0.00
```

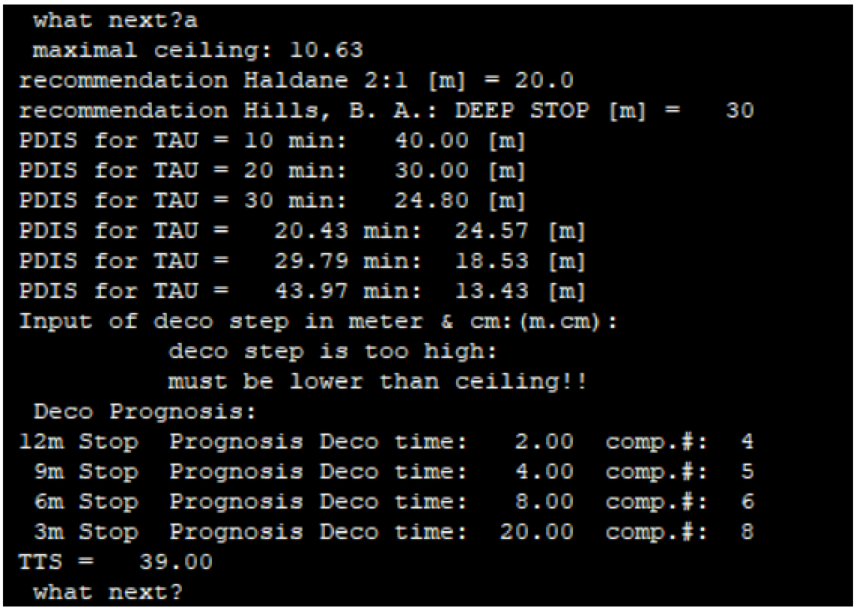
You see all the stages you keyed in and the ascents, all with the used gas. The composition of the mix gas is adapted with „m“, your SAC with „v“.

17 TEC Diving

Now let’s do a little TEC dive with normoxic Trimix and accelerated deco:
dive to 50 m for 20 min with Tmx 20/40/40, that is 20 % Oxygen, 40 % Helium, balance Nitrogen:

commands:

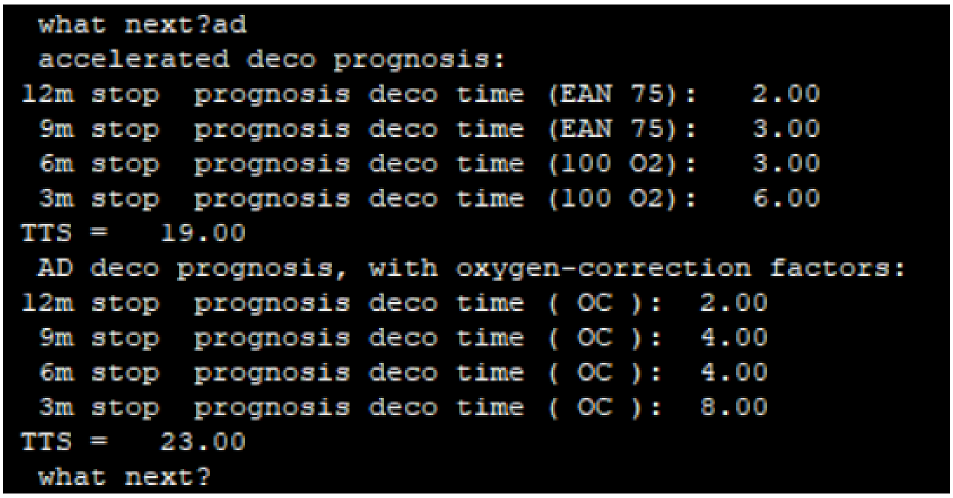
„m“ „.2“ „.4“ „d“ „50.“ „20.“ „a“ „ “ („“ is equivalent to „0.0“)



```
 what next?a
 maximal ceiling: 10.63
recommendation Haldane 2:1 [m] = 20.0
recommendation Hills, B. A.: DEEP STOP [m] =   30
PDIS for TAU = 10 min:   40.00 [m]
PDIS for TAU = 20 min:   30.00 [m]
PDIS for TAU = 30 min:   24.80 [m]
PDIS for TAU =   20.43 min:  24.57 [m]
PDIS for TAU =   29.79 min:  18.53 [m]
PDIS for TAU =   43.97 min:  13.43 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
12m Stop  Prognosis Deco time:   2.00  comp.#:  4
 9m Stop  Prognosis Deco time:   4.00  comp.#:  5
 6m Stop  Prognosis Deco time:   8.00  comp.#:  6
 3m Stop  Prognosis Deco time:  20.00  comp.#:  8
TTS =   39.00
 what next?
```

17-1: Standard deco prognosis ("a")

The TTS comes with the deco on back-gas, i.e. the TMx. If you want to expedite, key in „ad“ for „accelerated decompression“ with EAN50, EAN75 & EAN98:



```
 what next?ad
 accelerated deco prognosis:
12m stop  prognosis deco time (EAN 75):   2.00
 9m stop  prognosis deco time (EAN 75):   3.00
 6m stop  prognosis deco time (100 O2):   3.00
 3m stop  prognosis deco time (100 O2):   6.00
TTS =   19.00
 AD deco prognosis, with oxygen-correction factors:
12m stop  prognosis deco time ( OC ):  2.00
 9m stop  prognosis deco time ( OC ):  4.00
 6m stop  prognosis deco time ( OC ):  4.00
 3m stop  prognosis deco time ( OC ):  8.00
TTS =   23.00
 what next?
```

17-2: accelerated deco ("ad")

The EANx are kicked in at their appropriate MODs at ca. 1.6 atm pO2. The „OC“ you see below are the oxygen correction factors: they do not play a decisive role for short deco stops. But you could already see via „asy“, the asymmetrical de-saturation, that the TTS will increase a little bit. More on the „oc“s and „asy“s in the corresponding chapters.

Remark

concerning the SAC default of 25 L/min: if you carry a full double-12, one stage-tank on the left, one on the right, a little argon-system for your dry suit, and 2 of everything (light, SMB, computer, you name it …) then this is probably not to much for the bottom-phase. Relaxing during deco could drop the SAC down to 11 – 13 L / min.

And then is there another remark, not directly related to our topic here, but to decompression in general: you could change your mix with „m“ all the way up to the surface, so running a so-called „optimal mix“ strategy, that is always very close to your desired pO_2, max, of say, 1.2 or 1.4 Bar: an electronic closed-circuit rebreather (CCR) will do this job via the „set point“ for you. Diving an open system (SCUBA) would imply carring a lot of different mixes / tanks. This in turn could end in a complicated and thus error-prone dive plan, and a night-mare in terms of logistics, weight and cost for the pile of tanks you have to fill, analyze and carry. So pro‘s handle this with a strategy of max. 3 mixes! By increasing the pO_2, the values of %CNS and the OTUs become slowly, slowly interesting. Thus the labels in the „p“ change from **white** to **red**, if the pO_2 >= ca. 1.6 atm.

With „m“ comes as well a little „ICD Warning“, if the change in the partial pressures from one inertgas to the other exceeds a certain limit.

Hint:

The OTU dose is according to the REPEX method (source: pls. cf. chapter 13), the %CNS dose is the usual NOAA / USN allowance in the range $0.55 < pO_2 < 1.6$ atm. For a $pO_2 > 1.6$ atm, DIVE uses a little bit more conservative values than the USN and at 2.2 atm is end of game (pls. cf. the little table below!). The USN values are no "exceptional exposures" as per the NOAA, but just a standard procedure. N.B.: But this standard procedure is valid only for 100 % O_2 and thus not for mix gas!

pO2 [atm]	NOAA [min]	NOAA exceptional exposure	USN [min]	DIVE, V3, [min]
1,2	210			
1,3	180	240		
1,4	150	180		
1,5	120	150		
1,6	45	120		**45**
1,7		75	240	**37,5**
1,8		60		**30**
1,9		45	80	**22,5**
2		30	25	**15**
2,1				**7,5**
2,2			15	**0**
2,3				
2,4				
2,5			10	
	100 %	**CNS**	**Dose**	

Table 2: 100 % CNS / Ox-Tox doses

Pls. keep in mind, that the pro‘s are handling this completely different: some procedures allow up to 3.0 Bar pO_2 for definitively more than a couple of minutes.

Sources: again the DCIEM diving manual [**28**]**,** and there, in the chapter on „C & R / commercial diving“-books**: [167], [168], [171], [193**].

And, how could you reach a $pO_2 > 1,6$ atm for deco? Very easy! You have pure oxygen in your little stage tank on your right side and start stopping around 6 to 7 m. Suddenly, a little bit of a current, some waves, or your diving buddy got muddled with the SMB and the reel, and, zag-zag, by helping him or her, you're down at 8, 9, 10, 12 m … If you want to read more on that, there is a link to an article in the „Tech Diving Magazine“: www.techdivingmag.com
(Issue #7, July 2012, pages: 16 - 22): www.techdivingmag.com/download007.asp
or there: Mother Nature is a Bitch: beyond a pO2 of 1.6

If you want to learn more on this topic: try to get a copy of the 1992 reprint of Donalds Book **[182],** Donald, Kenneth (1992) Oxygen and the diver, SPA Ltd, ISBN 1 85421 176 5

18 „P“ and the details in the graphical screen-plot

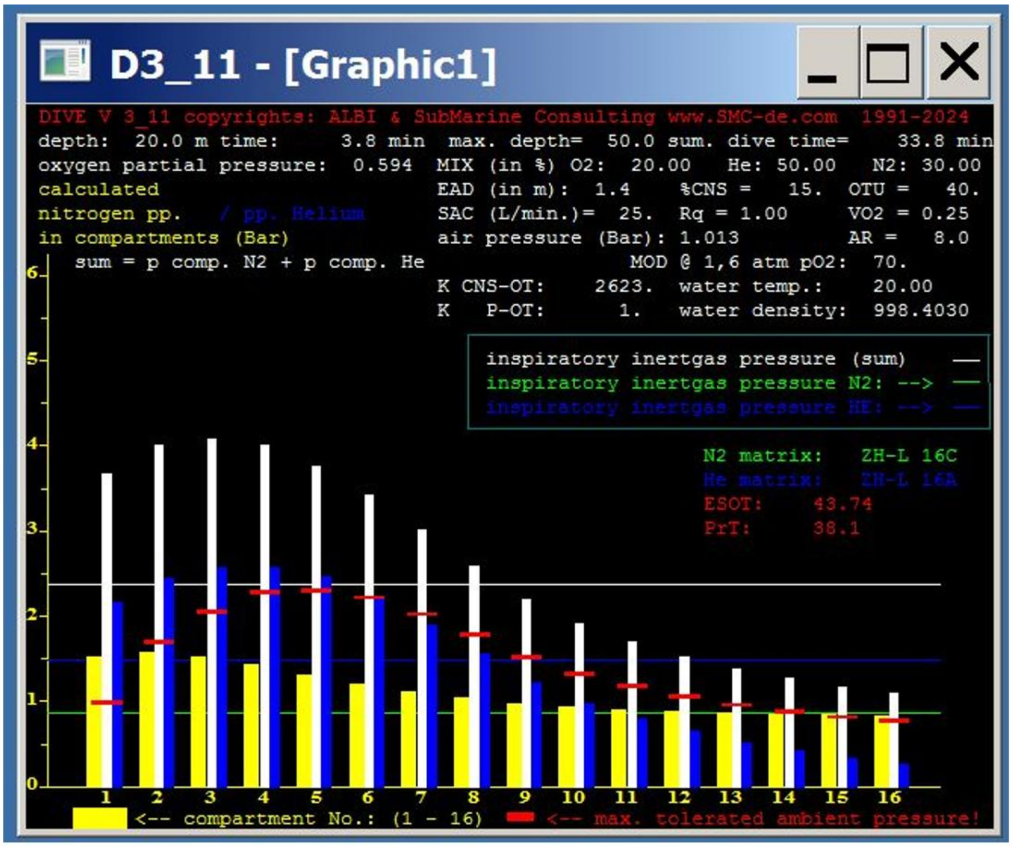
At any time you can generate a graphical output via „p“ (like: PLOT). We analyze the items in the P-screen with a TEC paradigm: 20 min @ 50 m, Tmx20/60 and an ascent to a deep stop @ 20 m.

By hitting the „Return“-key you leave this screen, with „alt“ + „Return“ you toggle between the windows and the full screen.

The next chart shows you this dive, along with explanations concerning the two main building blocks of the „p“-screen. These are:

- above: the parameter block of the dive
- below: the compartment block.

You see the topical depth of the deep stop (20 m), the time you used to get there and the sum of all. You see the maximal depth (50 m) and a wealth of other parameters. The height of the bar charts, the yellow and blue boxes give you an interesting information about the saturation status in comparison to the inspired pressures, the lines:



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2024
depth:  20.0 m time:      3.8 min  max. depth=  50.0 sum. dive time=    33.8 min
oxygen partial pressure:  0.594  MIX (in %) O2:  20.00   He: 50.00   N2: 30.00
calculated                       EAD (in m):  1.4    %CNS =    15.  OTU =    40.
nitrogen pp.   / pp. Helium      SAC (L/min.)=  25.  Rq = 1.00      VO2 = 0.25
in compartments (Bar)            air pressure (Bar): 1.013          AR =   8.0
   sum = p comp. N2 + p comp. He                MOD @ 1,6 atm pO2:  70.
                                 K CNS-OT:    2623.  water temp.:    20.00
                                 K   P-OT:       1.  water density:  998.4030

                                   inspiratory inertgas pressure (sum)     —
                                   inspiratory inertgas pressure N2: -->  —
                                   inspiratory inertgas pressure HE: -->  —

                                              N2 matrix:   ZH-L 16C
                                              He matrix:   ZH-L 16A
                                              ESOT:     43.74
                                              PrT:      38.1

   <-- compartment No.: (1 - 16)   <-- max. tolerated ambient pressure!
```

Compartment Block
topical parameter of 16 compartments:
number: # 1 → 16
calculated inertgas saturation (bar chart): N_2 (yellow); He (blue); sum (white)
inspiratory inertgas partial pressures (lines): N_2 (green); He (blue), sum (white)
maximal tolerated ambient pressures (dashes, red)

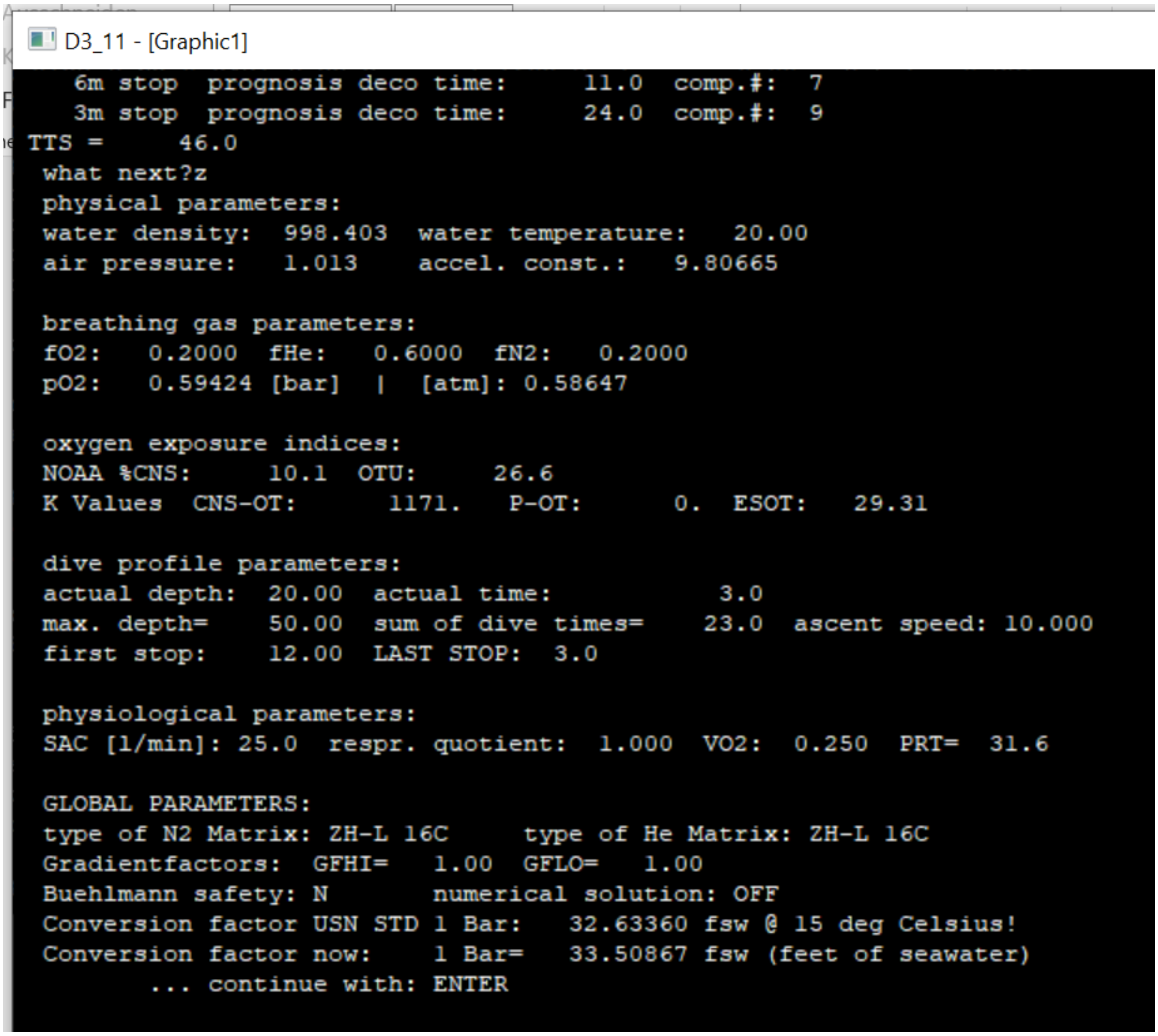
Parameter Block
topical parameters of the dive:
actual depth & time;
trailing pointer for maximal depth & complete dive time;
pO_2; gasmix; EAD

Ox-Tox dose NOAA:
%CNS & OTU;
K-Values, ESOT
MOD for
$PO_{2,\,max}$ = 1.6 atm
physiologic parameters:
SAC
(surface air consumption),
R_q
(respiratory quotient),
VO2
(O_2-consumption)
deco stress:PrT
ambient parameters:
amb. pressure;
ascent rate; water-temperature & -density

18-1: graphic screen via "p"

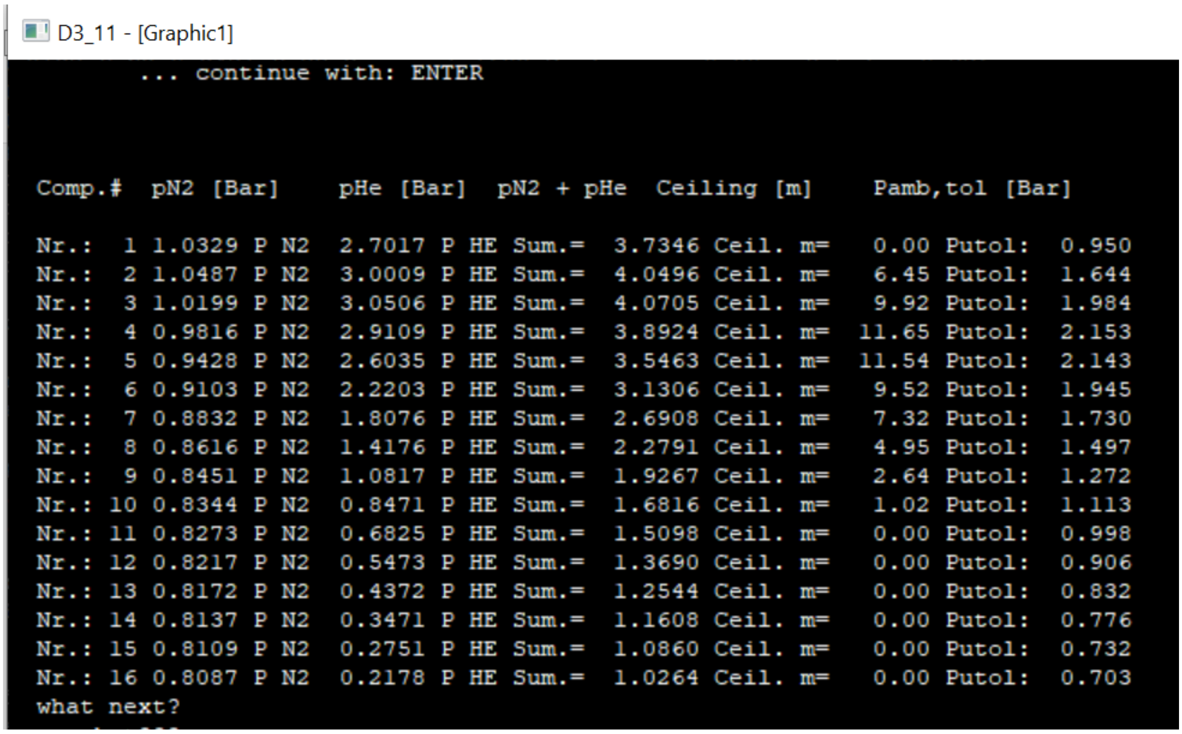
19 „Z“: show all relevant parameters

During the last couple of years, the new parameters have accumulated like a pile of old newspapers: we thus decided to re-design the alpha-numerical output from „z“ into 2 info-screens, as well there is now the pO_2 in [Bar] and [atm] for direkt comparison:



```
    6m stop  prognosis deco time:     11.0  comp.#:  7
    3m stop  prognosis deco time:     24.0  comp.#:  9
 TTS =      46.0
  what next?z
  physical parameters:
  water density:  998.403  water temperature:   20.00
  air pressure:   1.013    accel. const.:   9.80665

  breathing gas parameters:
  fO2:   0.2000  fHe:   0.6000  fN2:   0.2000
  pO2:   0.59424 [bar]  |  [atm]: 0.58647

  oxygen exposure indices:
  NOAA %CNS:      10.1  OTU:      26.6
  K Values  CNS-OT:      1171.   P-OT:       0.  ESOT:   29.31

  dive profile parameters:
  actual depth:  20.00  actual time:           3.0
  max. depth=    50.00  sum of dive times=    23.0  ascent speed: 10.000
  first stop:    12.00  LAST STOP:  3.0

  physiological parameters:
  SAC [l/min]: 25.0  respr. quotient:  1.000  VO2:  0.250  PRT=  31.6

  GLOBAL PARAMETERS:
  type of N2 Matrix: ZH-L 16C     type of He Matrix: ZH-L 16C
  Gradientfactors:  GFHI=   1.00  GFLO=   1.00
  Buehlmann safety: N       numerical solution: OFF
  Conversion factor USN STD 1 Bar:   32.63360 fsw @ 15 deg Celsius!
  Conversion factor now:    1 Bar=   33.50867 fsw (feet of seawater)
         ... continue with: ENTER
```

19-1: "Z": 1st. part of info screen



```
        ... continue with: ENTER


  Comp.#  pN2 [Bar]    pHe [Bar]  pN2 + pHe  Ceiling [m]    Pamb,tol [Bar]

  Nr.:  1 1.0329 P N2  2.7017 P HE Sum.= 3.7346 Ceil. m=  0.00 Putol:  0.950
  Nr.:  2 1.0487 P N2  3.0009 P HE Sum.= 4.0496 Ceil. m=  6.45 Putol:  1.644
  Nr.:  3 1.0199 P N2  3.0506 P HE Sum.= 4.0705 Ceil. m=  9.92 Putol:  1.984
  Nr.:  4 0.9816 P N2  2.9109 P HE Sum.= 3.8924 Ceil. m= 11.65 Putol:  2.153
  Nr.:  5 0.9428 P N2  2.6035 P HE Sum.= 3.5463 Ceil. m= 11.54 Putol:  2.143
  Nr.:  6 0.9103 P N2  2.2203 P HE Sum.= 3.1306 Ceil. m=  9.52 Putol:  1.945
  Nr.:  7 0.8832 P N2  1.8076 P HE Sum.= 2.6908 Ceil. m=  7.32 Putol:  1.730
  Nr.:  8 0.8616 P N2  1.4176 P HE Sum.= 2.2791 Ceil. m=  4.95 Putol:  1.497
  Nr.:  9 0.8451 P N2  1.0817 P HE Sum.= 1.9267 Ceil. m=  2.64 Putol:  1.272
  Nr.: 10 0.8344 P N2  0.8471 P HE Sum.= 1.6816 Ceil. m=  1.02 Putol:  1.113
  Nr.: 11 0.8273 P N2  0.6825 P HE Sum.= 1.5098 Ceil. m=  0.00 Putol:  0.998
  Nr.: 12 0.8217 P N2  0.5473 P HE Sum.= 1.3690 Ceil. m=  0.00 Putol:  0.906
  Nr.: 13 0.8172 P N2  0.4372 P HE Sum.= 1.2544 Ceil. m=  0.00 Putol:  0.832
  Nr.: 14 0.8137 P N2  0.3471 P HE Sum.= 1.1608 Ceil. m=  0.00 Putol:  0.776
  Nr.: 15 0.8109 P N2  0.2751 P HE Sum.= 1.0860 Ceil. m=  0.00 Putol:  0.732
  Nr.: 16 0.8087 P N2  0.2178 P HE Sum.= 1.0264 Ceil. m=  0.00 Putol:  0.703
  what next?
```

19-2: „z“: 2nd. part of the info screen

20 Deep Stops / way points

There is a build-in de-saturation ramp: for all prognosis, it assumes a certain constant ascent rate. For most dive computers / tables this defaults to 9 or 10 m / min. With „ar“ you could change it. As well you could do s.th. else: you dive on your way up („a“) to a so-called „way point“ and make your deep stops, or what ever, there. If you are below a calculated ceiling DIVE gives you a lot of hints for deep stops:

- Method Haldane is the usual pressure reduction ratio of 2:1
- Method Hills, according to Brian Andrew Hills, from his book „Decompression Sickness“ [102]
- PDIS (Profile Dependant Intermediate Stop) is the UWATEC method, where the compartment with HT = 20 min is checked. Additionally we put in 2 more compartments, just for comparison
- Is fHe > 0 (for your Tri-Mixes), then DIVE calculates as well the PDIS for these Helium compartments ...
- If you had changed previously via „NC“ or "HC", option 3 a coefficient matrix with the GF HI / LO unequal to 1.0, then DIVE will calculate as well the deco prognosis according to the „VGM“ (pl. cf. chapter 34)

Some hints:

1) a deco time of 0.0 means, that the compartment is already de-saturated; it does not contribute any longer to the deco-obligation.

2) deco time of 99.00 or the like implies a lower compartment saturation than the inspiratory one. So these compartments will still saturate during stops.

3) *****: value is too big (or too small) for display

21 Deco Prognosis and „b“

Additionally to the deep stop recommendations from „a“, DIVE shows a wealth of other deco procedures, available with „s“ or „pmrc“.

Hint:
The calculated compartment saturations will not be changed through any of the simulations from the tool box.

In the Buehlmann tables ([4], [5] resp. [65]: 2002, p. 165) there is an additional safety factor keyed in: calculated diving depth = planned depth * 1.03 + 1.0 m . With „**B“** you set this option, only thus you could compare the results from DIVE with the published tables.

22 Deco stress / PrT

Hempleman et al. of the RNPL (Royal Naval Physiological Laboratory) gave a simple criterion to asses the so-called „deco stress“. It is the „PrT“ criterion:

$$\mathbf{PrT = P_{amb} * Squareroot (T)}$$

P_{amb} it the pressure at working depth in Bar, T is the dive time of this *segment* in min.

If PrT > 25, P(DCS) rises significantly. DIVE adds the PrT-*values of all segments*,
for **PrT > 25** it will be displayed as red with „P“.

The sources of this pearl of wisdom are the following:

- `British Department of Energy, #TA /93/22/249 (1989)`
- Lambertsen CJ et al.: Development of Decompression Procedures“ EBSDC Report 7-28-1992, p. 11)
- [158] Shilling, C. W. Carlston, C.B. Mathias, R.A (1984) The Physician's Guide to Diving Medicine, Plenum Press, N.Y., ISBN-13: 978-1-4612-9663-8, p. 251 ff

Details to this and a comparison to other methods of assessing an inert gas dose is compiled in this Technical Report 2024_07:

On the Calculation of an Inert Gas Dose (10.07.2024)

https://dx.doi.org/10.13140/RG.2.2.32062.29769

23 Rebreather (SCR) dives

You could simulate as well dives for a SCR unit (semiclosed rebreather). This works because very much like a SCUBA system the SCR is „open“ concerning the feeding of the (pre-)mix into the (half open) breathing loop. A closed-circuit rebreather (CCR) works here in an other way and keeps the pO_2 constant.

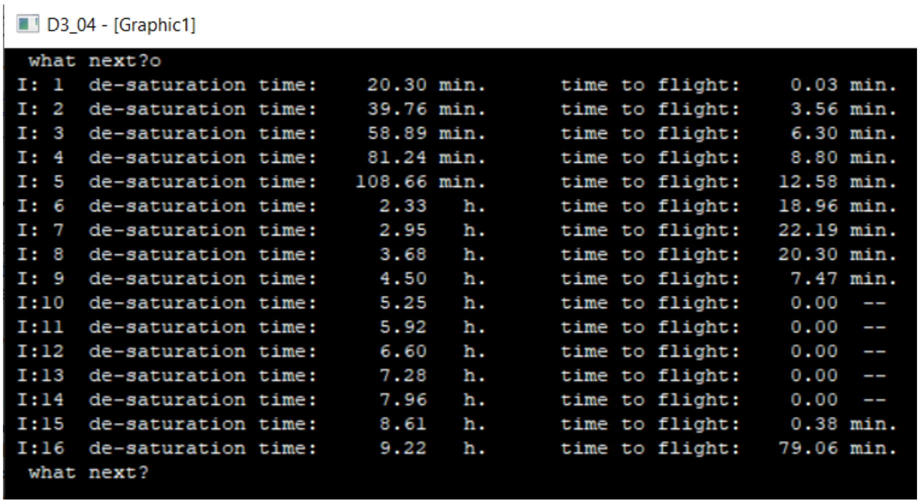
But you have to adapt for the peculiarities of a SCR, that is a reduced fO_2 in comparison to your used pre-mix from the EANx tanks. In the breathing bags of a SCR there is normally only 80% out of the offered pre-mix available, depending on your oxygen consumption and if you installed the correct orifice in your flow-control unit.

Eg.: take the DRAEGER DOLPHIN® with a pre-mix of EAN40. During standard operation you will find thus approx. 40 * 0.8 = 32 % of oxygen in your breathing bags. So you have to take „m“ with „0.32“ (instead of .4)

24 “O” = Time-to-Flight and desaturation

The „time-to-flight“ (no-fly-time) and the de-saturation time is available with „O“.
The time-to-flight is approximated via a supposed cabin pressure in a commercial aircraft with ca. 0.58 Bar.

The, more or less complete, de-saturation is approximated with a very small limit of a half of the daily average variation in the ambient air pressure. This is in the long run during a year ca. 0.02 Bar, so our limit in DIVE is 10 mbar:



```
 what next?o
I: 1  de-saturation time:    20.30 min.      time to flight:    0.03 min.
I: 2  de-saturation time:    39.76 min.      time to flight:    3.56 min.
I: 3  de-saturation time:    58.89 min.      time to flight:    6.30 min.
I: 4  de-saturation time:    81.24 min.      time to flight:    8.80 min.
I: 5  de-saturation time:   108.66 min.      time to flight:   12.58 min.
I: 6  de-saturation time:     2.33   h.      time to flight:   18.96 min.
I: 7  de-saturation time:     2.95   h.      time to flight:   22.19 min.
I: 8  de-saturation time:     3.68   h.      time to flight:   20.30 min.
I: 9  de-saturation time:     4.50   h.      time to flight:    7.47 min.
I:10  de-saturation time:     5.25   h.      time to flight:    0.00  --
I:11  de-saturation time:     5.92   h.      time to flight:    0.00  --
I:12  de-saturation time:     6.60   h.      time to flight:    0.00  --
I:13  de-saturation time:     7.28   h.      time to flight:    0.00  --
I:14  de-saturation time:     7.96   h.      time to flight:    0.00  --
I:15  de-saturation time:     8.61   h.      time to flight:    0.38 min.
I:16  de-saturation time:     9.22   h.      time to flight:   79.06 min.
 what next?
```

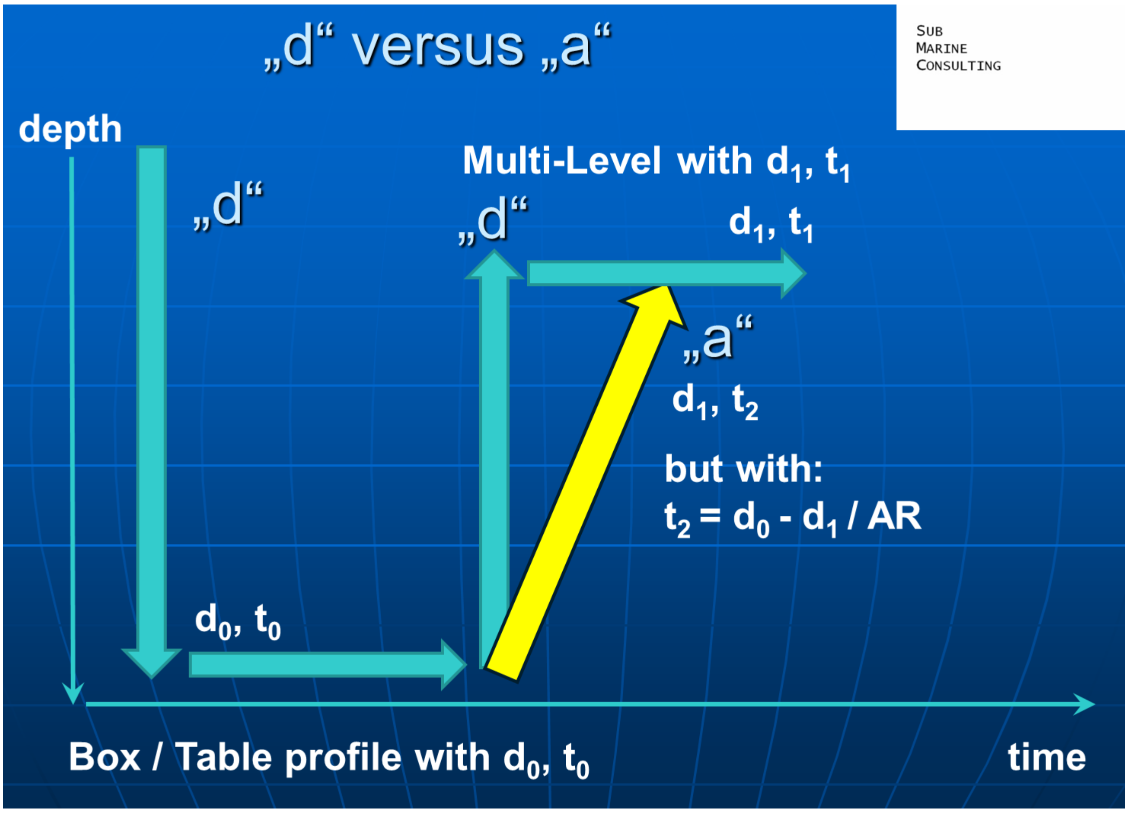
24-1: de-saturation and time-to-fly

For the exercise above, key in the data from one little NDL-dive:
„d“ „30.“ „15“ „a“ „o“:
the desaturation time per compartment (left) is much higher than the time-to-fly due to the smaller limit value. An average dive computer would display thus 10 h as a rounded up maximum of the calculated desaturation times and as time-to-fly probably 2 h.

There are dive computers which display only a count-down timer from 24 h after every dive, regardless the previous history of dives. And, pls. keep in mind the recommendation from the UHMS and of DAN of waiting minimum 24 h before entering an airplane.

25 „d“ versus „a“

With „d“ the pressure jumps instantaneously, with descent- or ascent speeds → infinity!



„d“ versus „a“

SUB
MARINE
CONSULTING

depth

„d“

Multi-Level with d_1, t_1

„d“

d_1, t_1

„a“

d_1, t_2

but with:

$t_2 = d_0 - d_1 / AR$

d_0, t_0

Box / Table profile with d_0, t_0

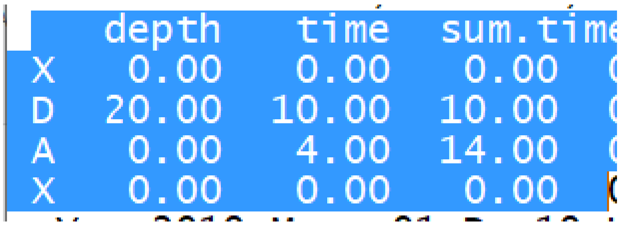
time

25-1: D versus A

Thus you could compare with published tables!

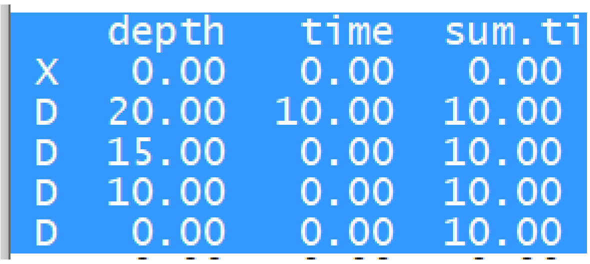
If you simulate an ascent, then the ascent rate („AR“) is taken into account and the time to the next stage is calculated as follows: $\Delta t = d_0 - d_1 / AR$.

You could see that as well in the run times, here with „AR“ = 5:



```
    depth    time    sum.time
X    0.00    0.00    0.00
D   20.00   10.00   10.00
A    0.00    4.00   14.00
X    0.00    0.00    0.00
```

With „d“ it runs like that, i.e.: AR is ignored:



```
    depth    time    sum.ti
X    0.00    0.00    0.00
D   20.00   10.00   10.00
D   15.00    0.00   10.00
D   10.00    0.00   10.00
D    0.00    0.00   10.00
```

26 Surface Mode / Dive Planer / rolling NDL Tables

Nearly all dive computers are offering these features: being in „surface mode“ they display immediately after dive a „rolling NDL table“. It displays normally the NDL for the next dive in the usual 3 m gaps from 12 to 40 m or so. The NDL are corrected with the inertgas load from the previous dives and thus, during increasing SI, will also start increasing again.

You could control your dive computers display with DIVE via a „deco stop at diving depth 0“:
„e“ „0.0“ „desired SI in min“ „t“
If your next dive is with EANx, change with „m“, then use the string of commands from above.

27 respiratory quotient

Via the „respiratory quotient“ we could adapt for workload and nutrition: $0.5 < R_q < 1.5$. Is the Rq small (fat nutrition, average workload) the ceiling sinks: i.e. the value becomes bigger. With a bigger Rq (carbohydrate nutrition, high workload) the ceiling rises, i.e. the value [in m] becomes smaller and closer to the surface. Default for R_q is = 1.0 (Buehlmann, Hahn and others), different for e.g. for the U.S.N. = 0.9.

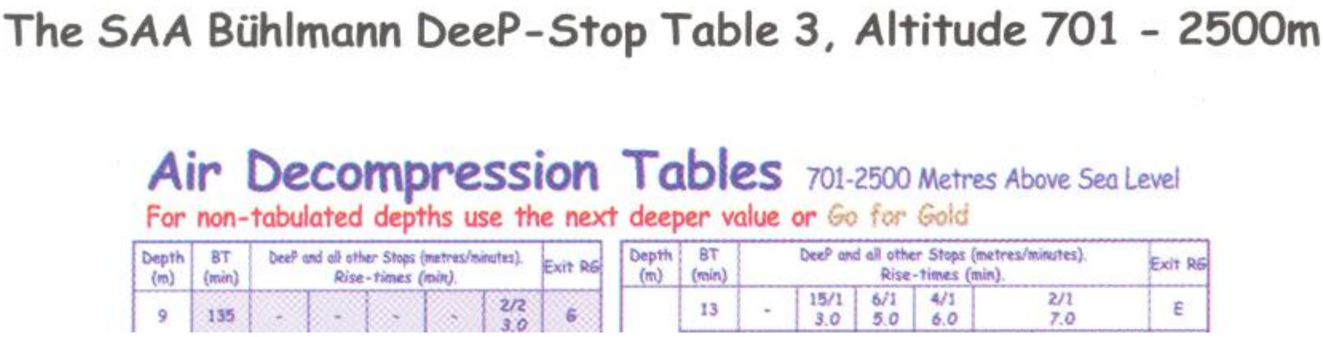
28 „L“ = Altitude Diving

„L“ is for the adaption of the ambient air pressure (defaults to ca. 1 atmosphere, 1.013 mbar). There is a rule of thumb: pressure reduction ca. 0.1 Bar per 1,000 m (1 km) increase in altitude. E.g.: if you dive the lake Tahoe which is approx. at 6,300 feet (ca. 2,000 m):
„L“ „0.8“
Then „t“ for a NDL table: you will see the reduced values, but without adaption of your body to this environment.

There are special tables for altitude diving available or you take the standard procedures from the USN diving manual or the DCIEM.

Attention: the implemented method here is the same for nearly all european altitude tables, valid for these types for eg.: ZH-83, ZH-86, Deco ’92, Deco 2000, SAA DeeP Stop Table #3. It is commonly referred to: „LEM“. LEM reads: **L**inear **E**xtrapolation of **M**-Values.

There is as well a living dive table out in the wild, derived from the ZH-L 16, but with deep stops:



The SAA Bühlmann DeeP-Stop Table 3, Altitude 701 - 2500m

Air Decompression Tables 701-2500 Metres Above Sea Level

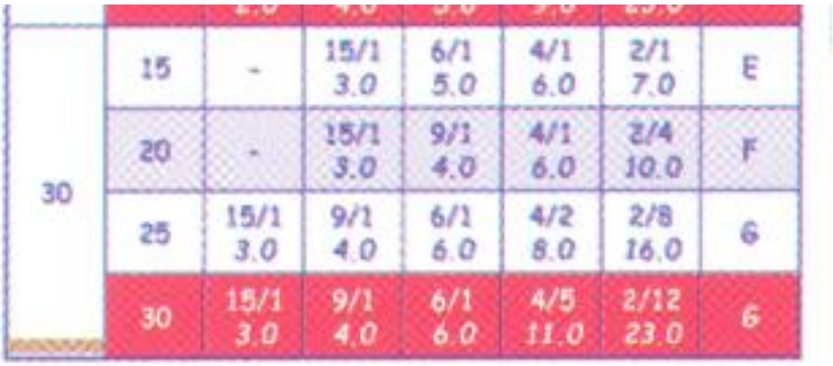
For non-tabulated depths use the next deeper value or Go for Gold

Depth (m)	BT (min)	DeeP and all other Stops (metres/minutes). Rise-times (min).					Exit RG
9	135	-	-	-	-	2/2 3.0	6

Depth (m)	BT (min)	DeeP and all other Stops (metres/minutes). Rise-times (min).					Exit RG
	13	-	15/1 3.0	6/1 5.0	4/1 6.0	2/1 7.0	E

28-1: SAA DeeP Stop @ altitude

A quick look at the 30 m entries reveals this one here:



30	15	-	15/1 3.0	6/1 5.0	4/1 6.0	2/1 7.0	E
	20	-	15/1 3.0	9/1 4.0	4/1 6.0	2/4 10.0	F
	25	15/1 3.0	9/1 4.0	6/1 6.0	4/2 8.0	2/8 16.0	G
	30	15/1 3.0	9/1 4.0	6/1 6.0	4/5 11.0	2/12 23.0	G

28-2: SAA DeeP Stop 30 m

You could simulate this one here as well and check, if it cuts the mustard …
The sources are these: [183], [185], [186], [187].

And, there is as well some in-depth science on it there:

- **A deep stop table for recreational dives on air: Debunked!**

https://dx.doi.org/10.13140/RG.2.2.24738.04800

There are as well a couple of other methods available. The one from PADI / USN, NAUI and also DCIEM are using the so-called **C**onstant **R**atio **T**ranslation (CRT); better known as the „Cross“ correction method after the guy’s name (Ellis Royal Cross, 1913 - 2000). It works with a fictiticious, increased diving depth. Which one is better or more safe can not be decided presently due to not enough data available.

Sources for the cited military diving manuals:
USN: https://www.navsea.navy.mil/Home/SUPSALV/00C3-Diving/Diving-Publications/
DCIEM: https://www.divetable.info/skripte/p125936.pdf
And the topical NOAA diving manual: [194]

Sources for other stuff concerning altitude diving:

https://www.divetable.info/skripte/Altitude_Diving.pdf

https://www.divetable.info/skripte/Altitude_Diving_II.pdf

and, as well: [**151**] Wienke, B.R. (1993) Diving above Sea Level, BPC, ISBN 0-941332-30-6, AND, this one, good news, for a free download there:
http://www.divetable.eu/151.pdf

29 Adaption / starting slope to the mountain lake

If you check with the above example via „p“ or „z“ your compartments, you will notice, that the reduced NDL are valid for your previous saturation at sea level. If you want to simulate your starting slope to the mountain lake, i.e.: your adaption time, key in a deco stop at diving depth 0.

30 Error / Out-of-Range

A very prominent difference from DIVE to a „living“ dive computer is the behavior during an error. Your dive computer normally runs into error mode with a lot of blinking, humming, beeping and error messages during: ascent speed too high, disregard of a deco obligation (in real time, the pressure difference between your deco stop and your topical depth may not exceed 0.8 Bar for 2 to 3 min), too deep, too long, too much pO_2 and the like, ending in freezing the display, falling back to „gauge mode“ (only dive time and topical depth is displayed, the decompression calculations are stopped) or a complete black out for 12 – 24 – 48 h. DIVE won’t do it: just a little error message with friendly reminders like „first complete ascent“ or „deco step is too high“. These things normally happen when the pure mathematics goes nuts, like division by zero or a logarithm from negative pressures.

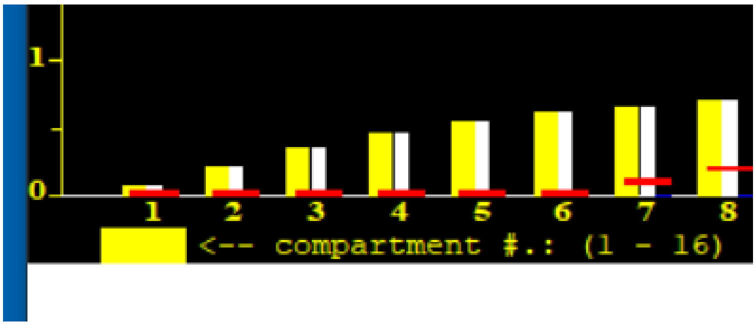
31 Prebreathing

Before „EVA“ (extra vehicular activity: yep, you could use DIVE as well for astronauts or aviators …) or a particular strenuous diving activity you could simulate pre-breathing: that is, breathing pure oxygen from a tank prior into the dive, not only to get a little bit of extra oxygen (not really, but i.e. removing H_20 and CO_2): but mainly to de-saturate delicate parts your body (the „fast“ compartments). Simulation of a 15 min pre-breathing goes very easy and like that:

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

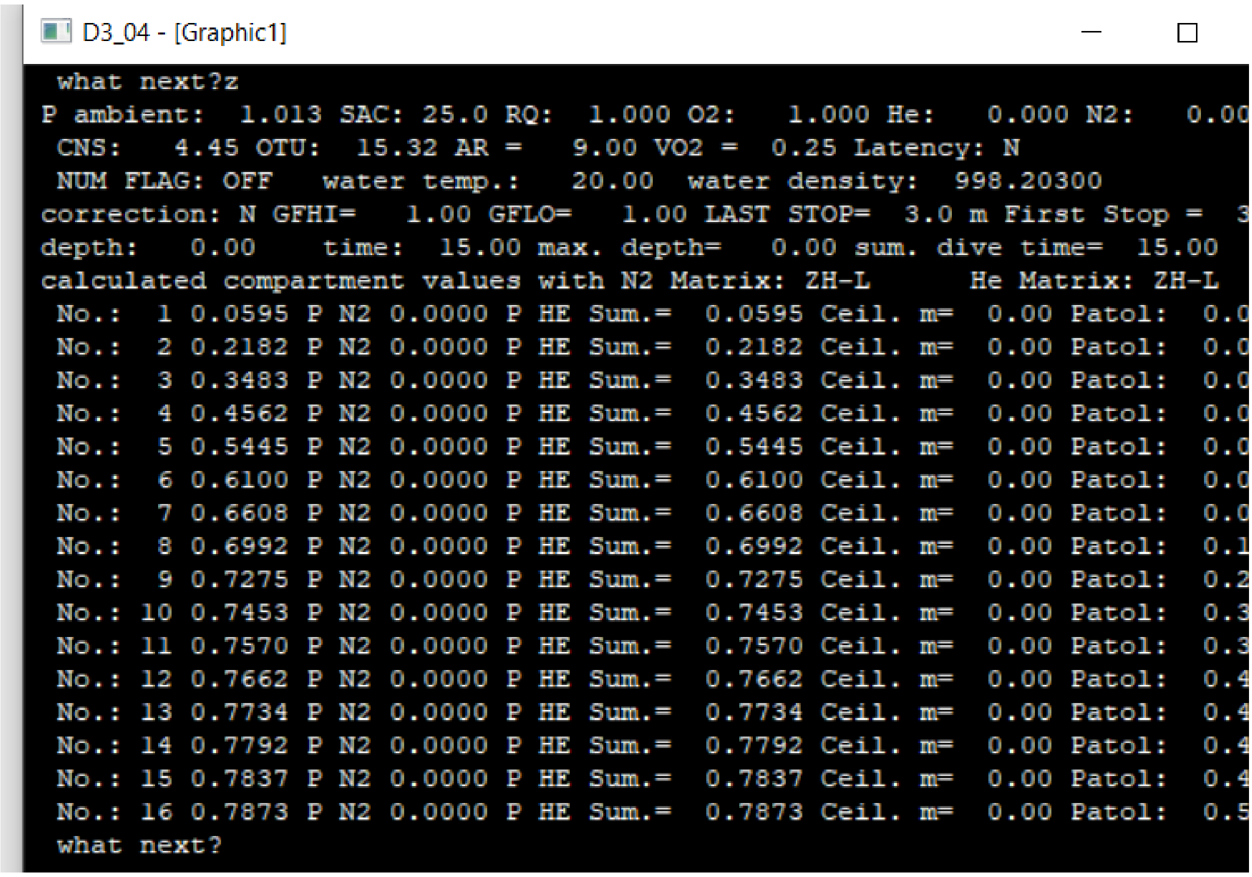
32 Diluent Hypoxy

The same procedure yields as well for other topics, like the „diluent hypoxy“ for the rebreather divers. This always occurs, if you did not put enough of your new breathing mix into the loop of your system, including your lungs prior to diving. The technical procedure is called „flushing the loop“; if you did not do it properly, a hypoxy may hit you. As well we could simulate the efficiency of mask-breathing in the deco-chamber. The BIBS cannot produce 100 % of pure oxygen ….



32-1: Pre-Breathing, diluent-hypoxy, BIBS, I.

The appropriate cemetry (via „z“) of numbers looks like that:



```
 what next?z
P ambient:  1.013 SAC: 25.0 RQ:  1.000 O2:   1.000 He:   0.000 N2:   0.00
 CNS:   4.45 OTU:  15.32 AR =   9.00 VO2 =  0.25 Latency: N
 NUM FLAG: OFF   water temp.:   20.00  water density:  998.20300
correction: N GFHI=  1.00 GFLO=  1.00 LAST STOP=  3.0 m First Stop =  3
depth:   0.00    time:  15.00 max. depth=  0.00 sum. dive time=  15.00
calculated compartment values with N2 Matrix: ZH-L      He Matrix: ZH-L
 No.:  1 0.0595 P N2 0.0000 P HE Sum.=  0.0595 Ceil. m=  0.00 Patol:  0.0
 No.:  2 0.2182 P N2 0.0000 P HE Sum.=  0.2182 Ceil. m=  0.00 Patol:  0.0
 No.:  3 0.3483 P N2 0.0000 P HE Sum.=  0.3483 Ceil. m=  0.00 Patol:  0.0
 No.:  4 0.4562 P N2 0.0000 P HE Sum.=  0.4562 Ceil. m=  0.00 Patol:  0.0
 No.:  5 0.5445 P N2 0.0000 P HE Sum.=  0.5445 Ceil. m=  0.00 Patol:  0.0
 No.:  6 0.6100 P N2 0.0000 P HE Sum.=  0.6100 Ceil. m=  0.00 Patol:  0.0
 No.:  7 0.6608 P N2 0.0000 P HE Sum.=  0.6608 Ceil. m=  0.00 Patol:  0.0
 No.:  8 0.6992 P N2 0.0000 P HE Sum.=  0.6992 Ceil. m=  0.00 Patol:  0.1
 No.:  9 0.7275 P N2 0.0000 P HE Sum.=  0.7275 Ceil. m=  0.00 Patol:  0.2
 No.: 10 0.7453 P N2 0.0000 P HE Sum.=  0.7453 Ceil. m=  0.00 Patol:  0.3
 No.: 11 0.7570 P N2 0.0000 P HE Sum.=  0.7570 Ceil. m=  0.00 Patol:  0.3
 No.: 12 0.7662 P N2 0.0000 P HE Sum.=  0.7662 Ceil. m=  0.00 Patol:  0.4
 No.: 13 0.7734 P N2 0.0000 P HE Sum.=  0.7734 Ceil. m=  0.00 Patol:  0.4
 No.: 14 0.7792 P N2 0.0000 P HE Sum.=  0.7792 Ceil. m=  0.00 Patol:  0.4
 No.: 15 0.7837 P N2 0.0000 P HE Sum.=  0.7837 Ceil. m=  0.00 Patol:  0.4
 No.: 16 0.7873 P N2 0.0000 P HE Sum.=  0.7873 Ceil. m=  0.00 Patol:  0.5
 what next?
```

32-2: Pre-Breathing, diluent-hypoxy, BIBS, II.

You see that during these 15 min of pre-breathing the compartments up to # 6 or 7 lost a lot of their initial N_2-saturation: good for you and good for your deco-status …

Now, for the serious scientist: if you have sensible postulations about the volume and the solubility coefficients of the very first compartments, you may exploit Henry’s Law and get a ball-park of how much N_2 the body really lost or how much „thinner“ your pre-mix became!

33 Isobaric Counterdiffusion (ICD)

Sources for ICD:

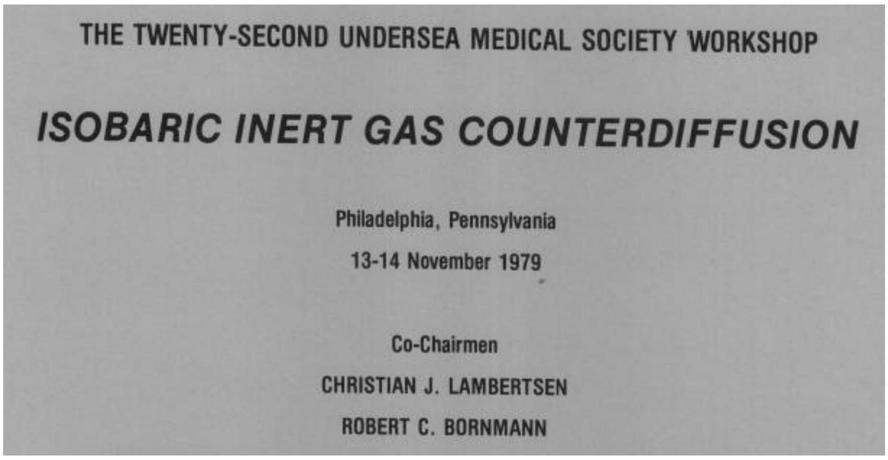
→ D. J. Graves, J. Idicula, C. J. Lambertsen and J. A. Quinn. Bubble Formation in Physical and Biological Systems: A Manifestation of Counterdiffusion in Composite Media, Science 179 (4073), 582-584. (February 9, 1973)

→ Strauss R.H., Kunkle T. D.: Isobaric Bubble Growth: A Consequence of Alterimg Atmospheric Gas. Science, Vol. 186, p. 443 – 444, 1974

→ LAMBERTSEN, C. J., AND J. IDICULA. A new gas lesion syndrome in man, induced by “isobaric gas counterdifusion." J. Appl. Physiol. 39(3) : 434-443. 1975

→ Hunter, TS Neuman and RF Goad (August 26, 1977), BG D'Aoust, KH Smith, HT Swanson, R White, CA Harvey, WL, Venous gas bubbles: production by transient, deep isobaric Counterdiffusion of helium against nitrogen, Science 197 (4306), 889-891.

→ UHMS workshop #22, 1979:


THE TWENTY-SECOND UNDERSEA MEDICAL SOCIETY WORKSHOP

ISOBARIC INERT GAS COUNTERDIFFUSION

Philadelphia, Pennsylvania
13-14 November 1979

Co-Chairmen
CHRISTIAN J. LAMBERTSEN
ROBERT C. BORNMANN

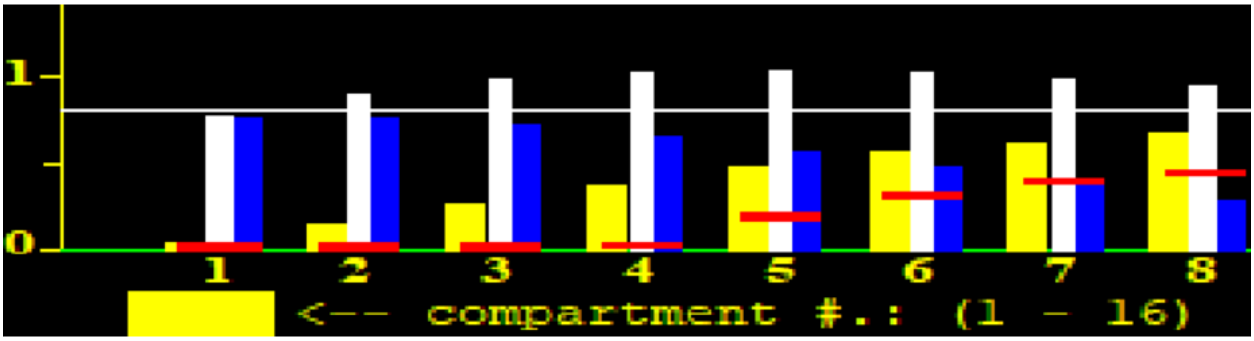
And, there is as well conflicting evidence for all this:

→ SAFE INNER EAR INERT GAS TENSION FOR SWITCH FROM HELIOX TO AIR BREATHING AT 100 FSW DURING DECOMPRESSION, Doolette DJ, Gerth WA, Gault KA, Murphy FGNavy Experimental Diving Unit, Panama City, FL. ASM 2012, Session F117

„The same procedure as every year?“ Yep, same procedure as per above is used, to simulate the so-called ICD. It takes always place if you change to a quickly diffusing gas, like the change from a sat dive with N_2 to He during deco.

Okay: excercise is breathing Heliox 20 min prior to dive:

via „m“ „ .2“ „ .8“ you get the guys a normoxic Heliox (20 % Oxygen, 80 % Helium) at „d“ = „0.0“ with say, during 20 mins: „20.0“ and check with „p“ and see, that the blue hill of He makes its march from left to right. That there is a real super-saturation, even beyond the ambient absolute pressure you may check in-depth with „z“, or, if you have a look at the sum of the partial pressures (white boxes), which exceed the inspired pressures (white line) by far:



33-1: ICD with normoxic Heliox after 20 min

This is possible as well in the reverse direction: after a Heliox- or Trimix dive the mix for deco is changed to EANx (with a lot of oxygen, if possible): so there will result an under-saturation relative to ambient pressure, and thus the inert gas gradient will expedite the deco-phase.

All these simulations are based on Grahams Law, that is He is by a factor of ca. 2.65 „faster“ (i.e. the N_2 HT are divided by this factor) than N_2. Mixgas tables and mixgas dive computers rely on that and the result for diving is the following: for trivial rec/TEC dives the deco stops starts one or two storeys deeper (in comparison to air) and becomes longer. This is colloquially called the „Helium Penalty“. But if this really cuts the mustard and is really valid for these sub-saturation dives is presently wide open: there are not enough resilient data available.

The sources of all this wisdom are:

→ D’Aoust, B.G., K. H. Smith, H.T. Swanson, R. White, L. Stayton, and J. Moore. 1979, Prolonged bubble production by transient isobaric counter-equilibration of helium against nitrogen. Undersea Biomed Res. 6(2): 109 -125)

→ Doolette DJ, Upton RN and Grant C. (2005). Perfusion-diffusion compartmental models describe cerebral helium kinetics at high and low cerebral blood flows in sheep. J Physiol. 563: 529–539

→ David J. Doolette , Richard N. Upton , Cliff Grant Journal of Applied Physiology Published 1 March 2015 Vol. 118 no. 5, 586-594 DOI: 10.1152/japplphysiol.00944.2014: Altering blood flow does not reveal differences between nitrogen and helium kinetics in brain or in skeletal miracle in sheep

34 Hints (more): the Tool Box

With:

„S“

(like „**S**imulation“) DIVE presents two different deco strategies:

- Safety Sur-Charges
- Conservativism-Factors

Safety Sur-Charges are simply add-ons, percent-wise. You could do it by heart the very moment, your dive computer displays any decompression obligation: they are rounded up to the next greater integer in minutes and are:

15, 20 and 25 %

The Conservativism-Factors (a la method COCHRAN, SUUNTO or MARES) are as well add-ons in percent, but not to deco-times, instead to the calculated inertgas saturations. In the manuals of the above cited manufacturers you will find these cryptically (i.e.: undocumented) as fitness or age-factors. These surcharges come normally in:

5, 10, 15 und 20 %.

With the command:

„PMRC“

(like: „Proportional M-Value Reduction Concept“) you have something that has been developped during ca. 2001 in the DAN DSL (Diving Safety Laboratory) in cooperation with UWATEC from Zuerich/Switzerland. It is just a reduction of certain M-Values. Proportional means in this context proportional to the Lambda (λ)-value, that is the inverse of the HT. In plaintext for divers: the shorter the HT, the bigger the reduction of their M-value. Thus this deco scenario presents deeper and longer stops.

Asymmetrical desaturation and the R/L Shunt (Right-to-Left Shunt):
J.S. Haldane already foresaw that bubbles and micro-bubbles would hinder a perfusion and thus the de-saturation due to the drag to blood or complete blocking of a vessel. With
„**ASY**“
this could be simulated. Standard tables or computers calculate saturation and desaturation in a symmetrical way, i.e.: the exponents are the same for on- as for off-gassing.

Another asymmetry comes with a high oxygen partial pressure into play:
„**oc**“ like **o**xygen **c**orrection factors. These are derived by measurements of the USN and the NMRC: they found, that a certain pO_2 for a certain time makes bradycardia and vasoconstriction. In plaintext for divers: the heart pace is reduced and the diameter of the blood vessels as well. All this contributes to a less efficient perfusion, that is: a less efficient off-gasing!

The sources for all this are:

- ➔ Role of oxygen in the production of human decompression sickness; Weathersby, Hart, Flynn, Walker; JAP 63(6): 2380 – 2387, 1987
- ➔ Inspired Oxygen pressure may have unexpected Effects on Inert Gas Exchange; Lundgren, Anderson, Nagasawa, Olszowka, Norfleet; Proceedings of the 40th UHMS workshop, p. 205 – 211, 1989
- ➔ Tikuisis P, Nishi R Y. Role of Oxygen in a Bubble Model for predicting Decompression Illness,DCIEM No. 94-04, January 1994
- ➔ Probabilistic models of the role of oxygen in human decompression sickness; Parker, Survanshi, Massell, Weathersby; JAP 84(3): 1096 – 1102, 1998
- ➔ Lillo, R. S., and E. C. Parker. Mixed-gas model for predicting decompression sickness in rats. J Appl Physiol 89: 2107–2116, 2000.

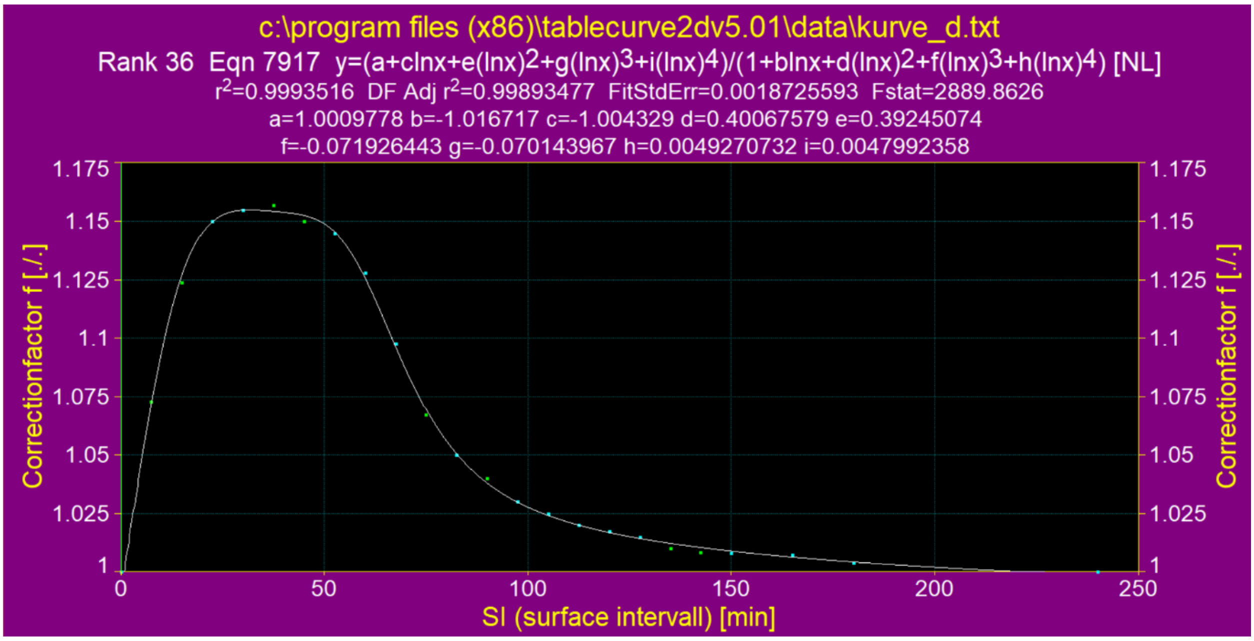
If DIVE sees a stop time at a pO_2 >= 1.6 atm and longer than 15 min it adds as well an air-break.

35 R-/L Shunt: „rl“ & „bsc“

With the „rl“ comes a simulation of a so-called pulmonary functional Right-to-Left shunt (R/-L shunt), that is: triggered via the ventilation of the lung. It runs during an SI of 0 to 180 min. Is the SI longer than 3 hours, then the R-/L shunt effect vanishes slowly slowly according to Buehlmann; Source:

- ➔ [65], p. 123,

The output is a corrected NDL table.
The basis is the curve D from p. 123; we fitted it with a non-linear function:



35-1: R-/L Shunt-Model from A.A.B.

The numerical simulation of a pulmonary R-/L shunt, used for corrected compartment-saturation during diving, is invoked with the mnemonic: „bsc“ (for: Bühlmann Shunt Correction): we made it work (contrary to the source!) for both N_2 AND Helium!

More details there:
Numerical simulation of a pulmonary R-/L shunt; Miri Rosenblat, TAU; Nurit Vered, Technion Haifa; Albi Salm, SubMarineConsulting @ TEC 4.0: update! 01/2024 ETH /IL

DOI: 10.13140/RG.2.2.23856.74245

36 Expert Mode: the coefficients matrix

This is a matrix with the salient parameters for all the „Post Haldane“ Perfusion-Decompression-Algorithms. Post Haldane are, in ca. timely order after the great John Scott Haldane:

Robert Dean Workman → Heinz R. Schreiner → Siegfried Ruff & Karl-Gerhard Müller → Robert William Hamilton → Edward Deforest Thalmann → Albert Alois Buehlmann → Max Hahn

Table 3: Post Haldane Perfusion Models

TAU is the HT, A and B are the coefficients describing per compartment the linear equation for the allowed/tolerated ambient pressures or super-saturations (M-values). The GF HI und GF LO are the gradient factors High and Low.

The transformation of the a- and b- coefficients from Buehlmann-Hahn et al. into the M and DeltaM (M_0, Δ M) -values of Bob Workman & Heinz Schreiner is easy and described at many places elsewhere, for eg. there:

Introduction to Decompression Calculation (01.03.2024

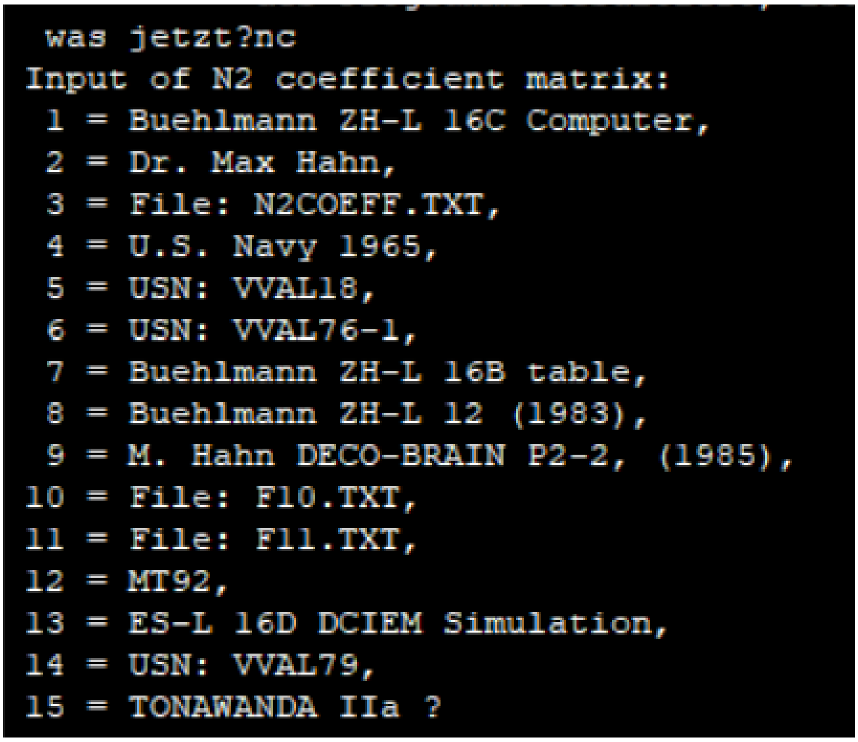
https://www.researchgate.net/publication/378653647_Introduction_to_Decompression_Calculation

This matrix can be manipulated via: „NC“ for N_2-coefficients an via „HC" for the Helium. Then you will be guided through a dialog with 15 options (and 7 for the Helium-part, „HC“):

1. these are the original Buehlmann coefficients (default)
2. Hahn coefficients, in approx. of the DECO 2000 table
3. file input of the file: N2COEFF.TXT (for N_2) resp. HECOEFF.TXT (for He). These files have to follow a certain form meticulously, otherwise DIVE will crash.
4. United States Navy, Method Workman from 1965
5. as well USN: but method of 2008, according to the coefficients „VVAL18“
6. and, again USN, the topical „VVAL76“, adapted Subset -1
7. and 8. the A.A. Bühlmann coefficient sets
9. one from Maxe Hahn for the Deco-Brain dive computer
10. and 11.: files, same format as per option 3.
12. the MT92 from the french air tables-set
13. the coefficients for a linear DCIEM simulation
14. USN: Vval79 coefficients
15. the Tonawanda IIa coefficients from the DCAP

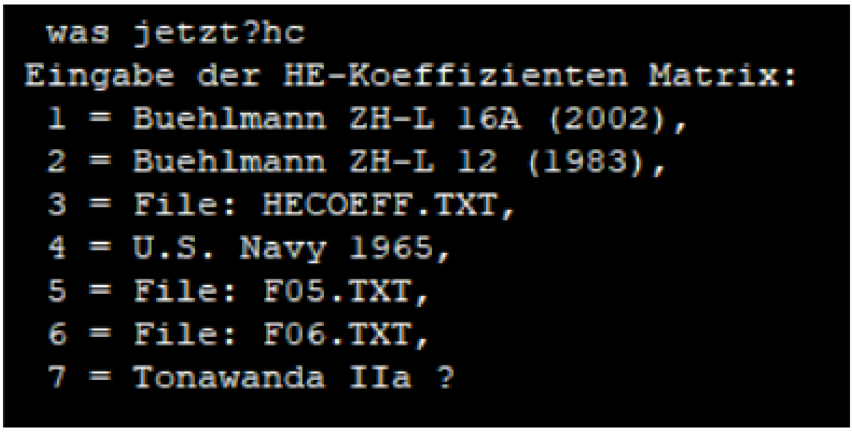
Details & „know-how“ concerning the TONAWANDA IIa coefficients are there:
Technical Report 2024_09:
TON IIa : on the use of the TONAWANDA IIa coefficients set
(03.09.2024)

https://dx.doi.org/10.13140/RG.2.2.28305.24165



```
 was jetzt?nc
Input of N2 coefficient matrix:
 1 = Buehlmann ZH-L 16C Computer,
 2 = Dr. Max Hahn,
 3 = File: N2COEFF.TXT,
 4 = U.S. Navy 1965,
 5 = USN: VVAL18,
 6 = USN: VVAL76-1,
 7 = Buehlmann ZH-L 16B table,
 8 = Buehlmann ZH-L 12 (1983),
 9 = M. Hahn DECO-BRAIN P2-2, (1985),
10 = File: F10.TXT,
11 = File: F11.TXT,
12 = MT92,
13 = ES-L 16D DCIEM Simulation,
14 = USN: VVAL79,
15 = TONAWANDA IIa ?
```

36-1: the 15 Options of "NC"



```
 was jetzt?hc
Eingabe der HE-Koeffizienten Matrix:
 1 = Buehlmann ZH-L 16A (2002),
 2 = Buehlmann ZH-L 12 (1983),
 3 = File: HECOEFF.TXT,
 4 = U.S. Navy 1965,
 5 = File: F05.TXT,
 6 = File: F06.TXT,
 7 = Tonawanda IIa ?
```

36-2: the 7 Options of "HC"

Hint:
If you want to compare DIVE with the published USN tables, make sure you understand how they have created them and adapt the following: feet → meter, seawater density, R_q, „LS“, „ASY“, „L“ and „AR“. And a bitter pill: we have put the parameter SDR, the so-called „Saturation/Desaturation Ratio“, from 0.7 to 1.0 and the „EL-kick in“ parameter P_{xo} to infinity …

Attention:
Do not change the coefficients during a simulation, and as well: „CLR“ does not clear any matrices, **on purpose**!

The sources for all these matrices are the following:

→ Workman, Robert D. "Calculation of Decompression Tables for Nitrogen-Oxygen and Helium-Oxygen Dives," Research Report 6-65, U.S. Navy Experimental Diving Unit, Washington, D.C. (26 May 1965)

→ Hempleman, H.V. „British decompression theory and practice“, in: Bennet, P.B., Elliot, D.H.:“The Physiology and Medicine of Diving and Compressed Air Work“, 1st ed., Bailliere, Tindall and Cassell, London 1969

→ Schreiner, H.R., and Kelley, P.L. "A Pragmatic View of Decompression," Underwater Physiology Proceedings of the Fourth Symposium on Underwater Physiology, edited by C.J. Lambertsen. Academic Press, New York, (1971) pp. 205-219

→ Kidd, D.J., R.A. Stubbs and R.S. Weaver „Comparative approaches to prophylactic decompression“, in: Lambertsen, C.J.: “Underwater Physiology, Proceedings of the Fourth Symposium on Underwater Physiology“, Academic Press, New York 1971.

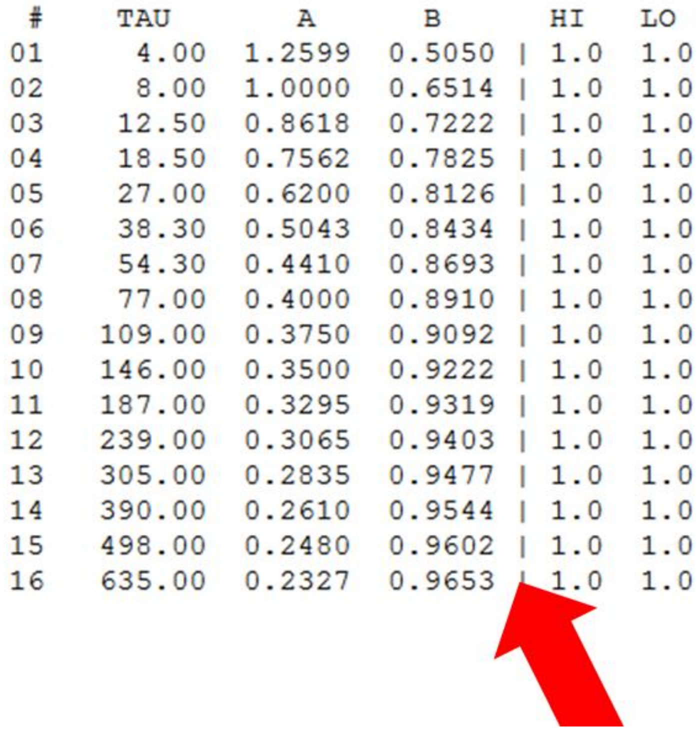
→ AND: a handful of these USN NEDU Technical Reports:
VVAL76: NEDU TR 03-2009, p. D-1
AND: TR 09-2007, Appendix B-1 & C-1
VVAL18 & VVAL 18-1: NEDU TR 12-2003, p.32
AND: NEDU Report 1-84, p. 14
VVAL 79: TA 10-12, NEDU TR 12-01, MAR 2012, p. 11

So the timeline was, cum grano salis, s.th. like that: VVAL18→18M→76→77→79→82.

For the file-input option 3:

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

are the expected places for theses files. The form has to be exactly like that, eg. here for N_2:



```
 #     TAU      A       B       HI   LO
01     4.00  1.2599  0.5050 |  1.0  1.0
02     8.00  1.0000  0.6514 |  1.0  1.0
03    12.50  0.8618  0.7222 |  1.0  1.0
04    18.50  0.7562  0.7825 |  1.0  1.0
05    27.00  0.6200  0.8126 |  1.0  1.0
06    38.30  0.5043  0.8434 |  1.0  1.0
07    54.30  0.4410  0.8693 |  1.0  1.0
08    77.00  0.4000  0.8910 |  1.0  1.0
09   109.00  0.3750  0.9092 |  1.0  1.0
10   146.00  0.3500  0.9222 |  1.0  1.0
11   187.00  0.3295  0.9319 |  1.0  1.0
12   239.00  0.3065  0.9403 |  1.0  1.0
13   305.00  0.2835  0.9477 |  1.0  1.0
14   390.00  0.2610  0.9544 |  1.0  1.0
15   498.00  0.2480  0.9602 |  1.0  1.0
16   635.00  0.2327  0.9653 |  1.0  1.0
```

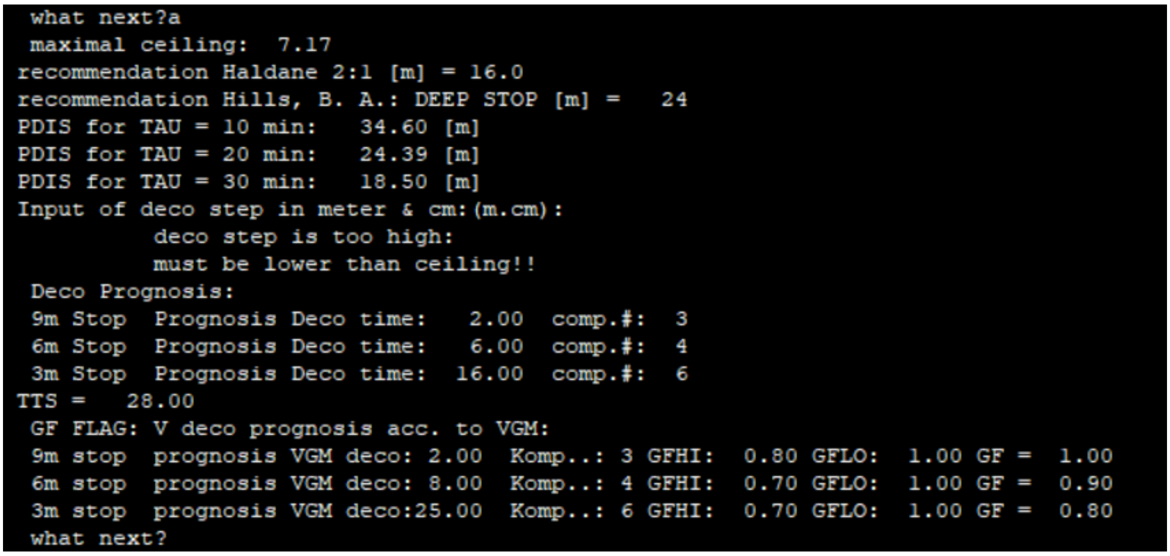
36-3: example for nitrogen coefficients matrix

incl. the blanks! Just as an optical demarcation line between perfusionconstants and the GF there are these signs: (**|**), pls. cf. at the red arrow above.

With any ASCII Editor (e.g.: NOTEPAD) you could now change the values. After the input of this file via option 3 follows immediately an output on the screen: you can control if everything is according to your wishes. If not, change again via the editor, and again option 3. You may change everything **within the pre-defined formats, but not the index 1- 16.**

Hint: it does not make much sense to take, for eg. the Hahn coefficients and then running afterwards a PMRC: the hang-times will just sky-rocket … As well there are physiologic boundaries in changing the coefficients haphazardly: they are connected to each other via the HT. But there are situations which would make sense, for eg. taking s.th. like a COCHRAN matrix and then looking, what a PMRC does with it … ok, ok: this is, why it is called the „expert mode“ ….

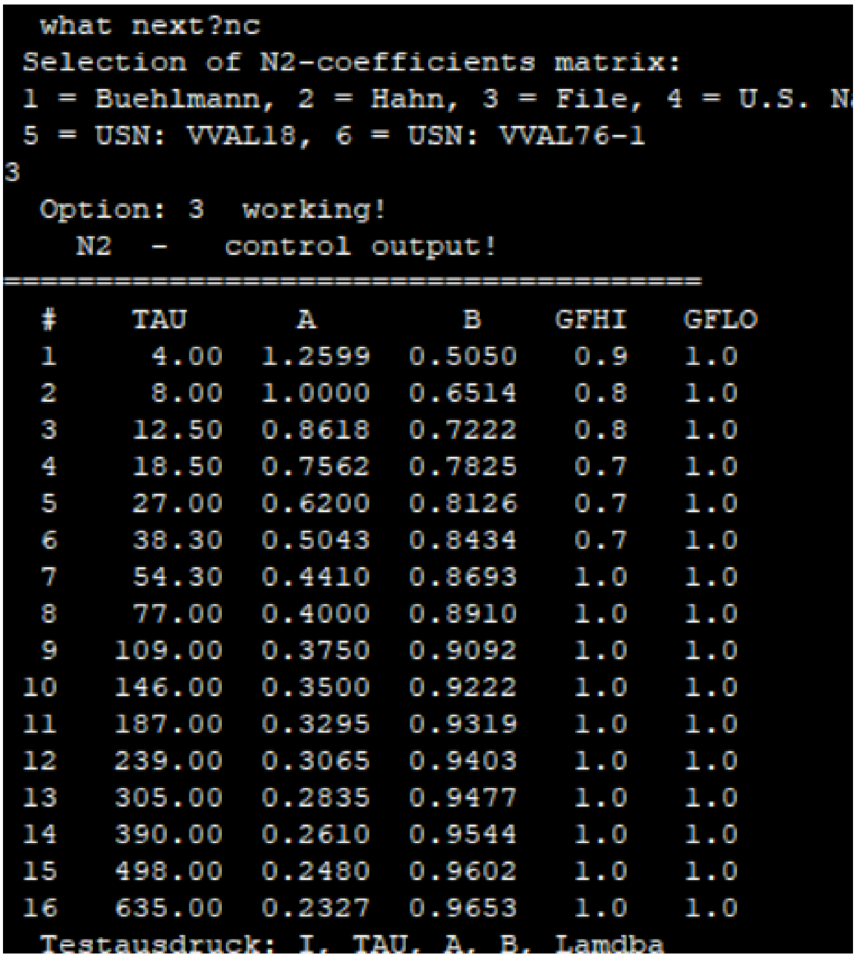
If in the matrices only ONE of the GF HI / LO is changed, DIVE assumes the VGM method and a subsequent prognosis will take this form:



```
 what next?a
 maximal ceiling:  7.17
recommendation Haldane 2:1 [m] = 16.0
recommendation Hills, B. A.: DEEP STOP [m] =   24
PDIS for TAU = 10 min:   34.60 [m]
PDIS for TAU = 20 min:   24.39 [m]
PDIS for TAU = 30 min:   18.50 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
 9m Stop  Prognosis Deco time:   2.00  comp.#:  3
 6m Stop  Prognosis Deco time:   6.00  comp.#:  4
 3m Stop  Prognosis Deco time:  16.00  comp.#:  6
TTS =   28.00
 GF FLAG: V deco prognosis acc. to VGM:
 9m stop  prognosis VGM deco: 2.00  Komp..: 3 GFHI:  0.80 GFLO:  1.00 GF =  1.00
 6m stop  prognosis VGM deco: 8.00  Komp..: 4 GFHI:  0.70 GFLO:  1.00 GF =  0.90
 3m stop  prognosis VGM deco:25.00  Komp..: 6 GFHI:  0.70 GFLO:  1.00 GF =  0.80
 what next?
```

36-4: Variable Gradient Method (VGM)

Here you see for 3 compartments 3 variable gradients. Prior to reading the file via option 3 in „nc“, you have to edit, eg. like that:



```
  what next?nc
 Selection of N2-coefficients matrix:
 1 = Buehlmann, 2 = Hahn, 3 = File, 4 = U.S. N
 5 = USN: VVAL18, 6 = USN: VVAL76-1
3
  Option: 3  working!
    N2   -   control output!
======================================
  #    TAU       A        B      GFHI   GFLO
  1     4.00  1.2599  0.5050    0.9    1.0
  2     8.00  1.0000  0.6514    0.8    1.0
  3    12.50  0.8618  0.7222    0.8    1.0
  4    18.50  0.7562  0.7825    0.7    1.0
  5    27.00  0.6200  0.8126    0.7    1.0
  6    38.30  0.5043  0.8434    0.7    1.0
  7    54.30  0.4410  0.8693    1.0    1.0
  8    77.00  0.4000  0.8910    1.0    1.0
  9   109.00  0.3750  0.9092    1.0    1.0
 10   146.00  0.3500  0.9222    1.0    1.0
 11   187.00  0.3295  0.9319    1.0    1.0
 12   239.00  0.3065  0.9403    1.0    1.0
 13   305.00  0.2835  0.9477    1.0    1.0
 14   390.00  0.2610  0.9544    1.0    1.0
 15   498.00  0.2480  0.9602    1.0    1.0
 16   635.00  0.2327  0.9653    1.0    1.0
  Testausdruck: I, TAU, A, B, Lamdba
```

36-5: Example for edited coeffcients for VGM

<u>Now, if you want to check your competence with DIVE: want a little brain-twister???</u>

How would you use DIVE in an efficient & elegant way to re-produce an old original Haldane table?

Source: Boycott, A.E., Damant, G.C.C., & Haldane, J.S.: The Prevention of Compressed Air Illness, Journal of Hygiene, Volume 8, (1908), pp. 342-443.

→ Little hint: modify the columns at a- and b- to reach at a „2:1“ relationship

→ Another one: from the 6th. compartment on use only the values from the 5th.: Haldane had as well only 5 compartments.

Finally, a couple of illuminating questions:
→ the guy had had seawater under keel, hadn’t he? So just changing feet to m will not do the job, or?

→ And, BINGO: did he take oxygen into account or did he calculate with just $fN_2 = 1.0$???

So, would you change all geometrical depth readings according to an „inverted EAD“ like:
((depth in table + 10.) / 0.79) – 10. = depth for calculating
Would you?

More to this in, and all the references therein:

> Tech Diving Mag, Issue 25 / 2016:
> **Did Haldane really use his "2:1"?**
>
> **in theTDM archive there:**
> TECH DIVING MAG (TDM), the real TECHNICAL DIVING MAGAZINE (TDM, 12/2010 - 09/2018) (divetable.eu)
> or there this paper:
> https://dx.doi.org/10.13140/RG.2.2.21318.91209

If you still did not get a grip on it: have a look at the HALDANE.TXT file from the DIVE.zip archive: this is a coeffcient matrix you may use for „nc“, the option 3.

37 „LS“ = the „last stop“ option

The usual last stop is at 3 m: this stems as well from good old Haldane, who put it in 10 feet increments. With „ls“ you adapt it to your specific situation:

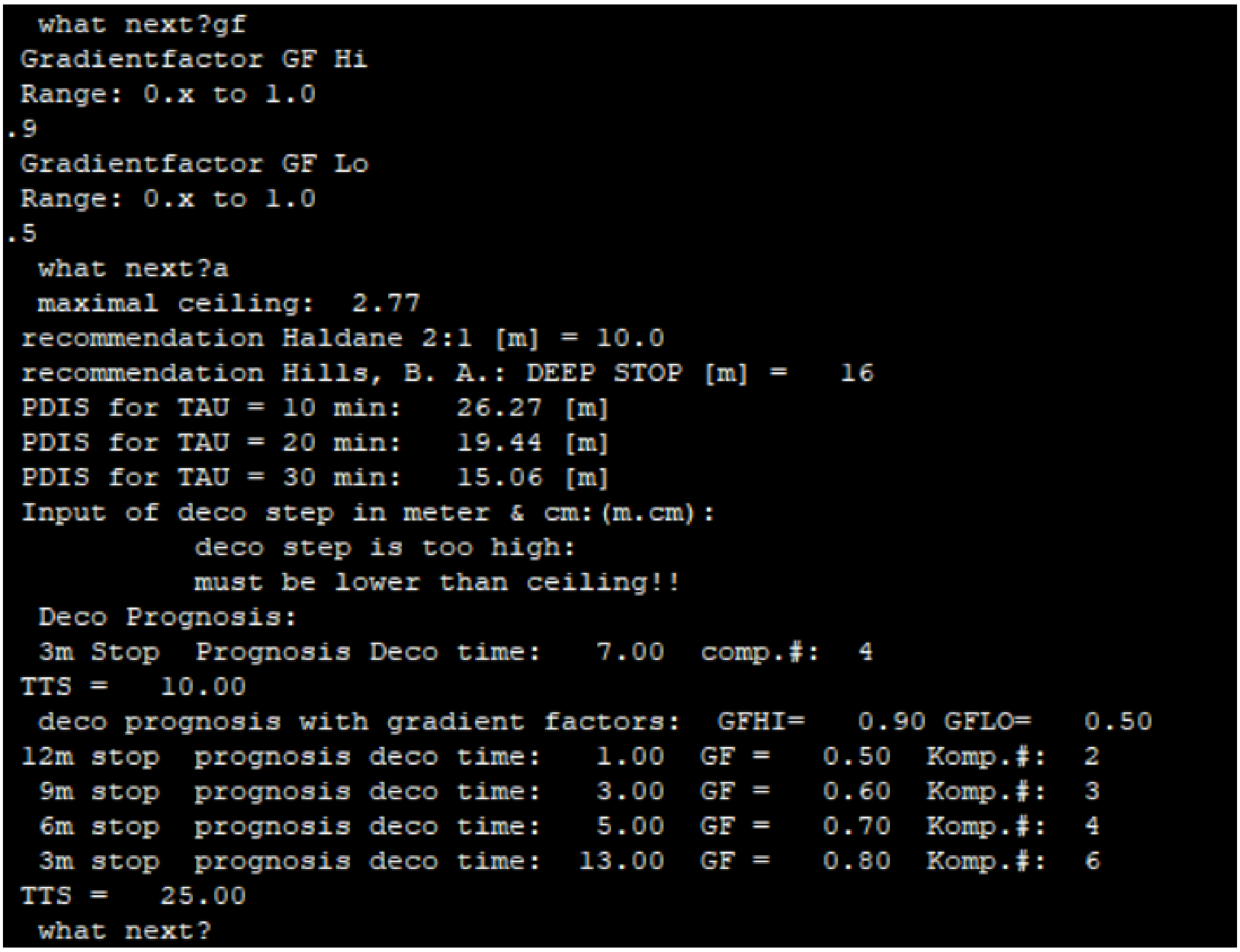
- altitude diving: at reduced ambient pressure the last stop is usually around 2 m
- current, tide, swell, sea, shipping traffic: there are a lot of situations where it is much safer to stay deeper than 3 m
- Mix gas: with Helium in the mix, the last stop is usually around 4 to 6 m
- Accelerated Deco / 100 % O_2: the most efficient desaturation takes place between 6 to 9 m
- USN Table, Rev. 6 / 2008 resp. USN Rev. 7 / Dec. 2016: the last stops are only at the 20 feet margin!
- Commercially available Heliox-tables are having the last stop regularly at 9m

38 „GF“ = the gradient factors

Via the input of a GF HI (=High, at the surface) and a GF LO (=Low, at the deeper stops) you can compel DIVE to a more conservative deco prognosis, without changing the coefficients matrix. That is: you key in just 2 numbers, this yields for the complete flock of ALL compartments. If you want to do it in a granular way, i.e. per compartment, you could use the „VGM method“ (next chapter).

The standard useage of the GFs runs like that: both GF < 1.0 and GF HI > GF LO.
Want an example?

Dive on air, 30 m / 30 min and GF HI = 0.9, GF LO = 0.5 yields the following:



```
  what next?gf
 Gradientfactor GF Hi
 Range: 0.x to 1.0
.9
 Gradientfactor GF Lo
 Range: 0.x to 1.0
.5
  what next?a
  maximal ceiling:  2.77
 recommendation Haldane 2:1 [m] = 10.0
 recommendation Hills, B. A.: DEEP STOP [m] =   16
 PDIS for TAU = 10 min:   26.27 [m]
 PDIS for TAU = 20 min:   19.44 [m]
 PDIS for TAU = 30 min:   15.06 [m]
 Input of deco step in meter & cm:(m.cm):
           deco step is too high:
           must be lower than ceiling!!
  Deco Prognosis:
  3m Stop  Prognosis Deco time:   7.00  comp.#:  4
 TTS =   10.00
  deco prognosis with gradient factors:  GFHI=   0.90 GFLO=   0.50
 12m stop  prognosis deco time:   1.00  GF =   0.50  Komp.#:  2
  9m stop  prognosis deco time:   3.00  GF =   0.60  Komp.#:  3
  6m stop  prognosis deco time:   5.00  GF =   0.70  Komp.#:  4
  3m stop  prognosis deco time:  13.00  GF =   0.80  Komp.#:  6
 TTS =   25.00
  what next?
```

38-1: dive 30 m / 30 min with GF HI = 0.9 & GF LO = 0.5

GF LO starts here at 0.5 and forces the deeper stops at 12, 9 and 6 m (instead of 3 m), the deco time at 3 m is also increased from 7 to 13 min due to the GF HI. You see as well which compartment is affected (right) and how the GF varies in a linear fashion from 0.5 to 0.9 by reaching the surface, so the TTS is increased from ca. 10 to 25.

More hints and a friendly warning: there are physiologic boundaries to these GF’s! When a GF Lo comes close to 0.4, it could, depending on the HT, touch the ambient pressure line and the subsequent allowed super-saturation becomes very, very small. For real-world diving this is not really useful.

And, last hint: it is quite a standard in a deco-software to have the GF’s from a range within 0.x → 1.0 But nobody hinders you, to put a GF > 1.0, so you could play a little bit with it. Try the following with our usual test-dive (42.0 m, 25.0 min) and key-in the following GFs:

→ GF High: 1.15
→ GF Low: 0.6

There results:

```
  Deko Prognose:
  9m Stopp Prognose Dekozeit:     2.0  Komp.#:  3
  6m Stopp Prognose Dekozeit:     6.0  Komp.#:  4
  3m Stopp Prognose Dekozeit:    16.0  Komp.#:  6
 TTS =     28.0
  Deko Prognose mit Gradientenfaktoren:  GFHI=   1.15 GFLO=   0.60
 15m Stopp Prognose Dekozeit:     1.0  GF =   0.60  Komp.#:  2
 12m Stopp Prognose Dekozeit:     1.0  GF =   0.71  Komp.#:  3
  9m Stopp Prognose Dekozeit:     3.0  GF =   0.82  Komp.#:  3
  6m Stopp Prognose Dekozeit:     6.0  GF =   0.93  Komp.#:  4
  3m Stopp Prognose Dekozeit:    13.0  GF =   1.04  Komp.#:  6
 TTS =     28.0
```

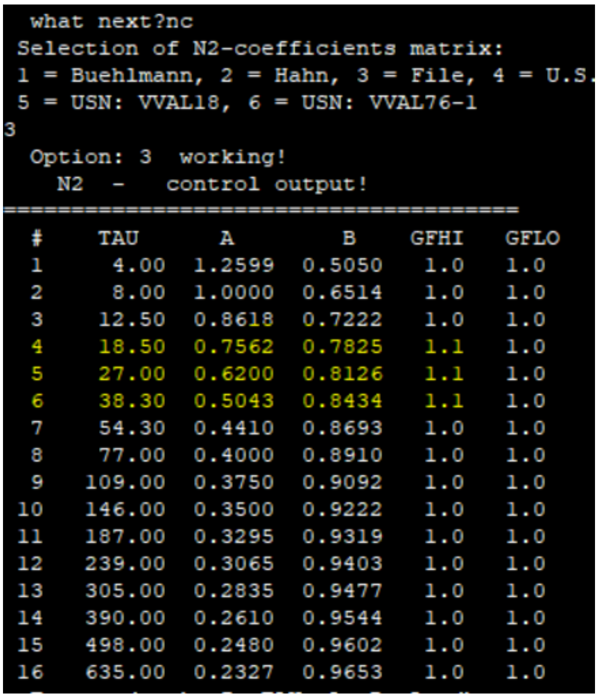
38-2: Test-Dive (42m, 25 min) with GF Hi = 1.15 & GF Lo = 0.6

an *aggressive RGBM*, that is with short, deep stops and truncated stops in the shallow. Here, the TTS is unchanged, just the stop times are re-distributed. With an increased GF Hi the shallow stops become even smaller …

39 VGM, the „Variable Gradient Method“

With the VGM the GF HI / LO could be adapted per compartment. As well you could put values > 1.0 in the matrix, implying a reduced stop time! That is, instead of a conservative deco you move in the other way, an aggressive deco with shortened hang-times.

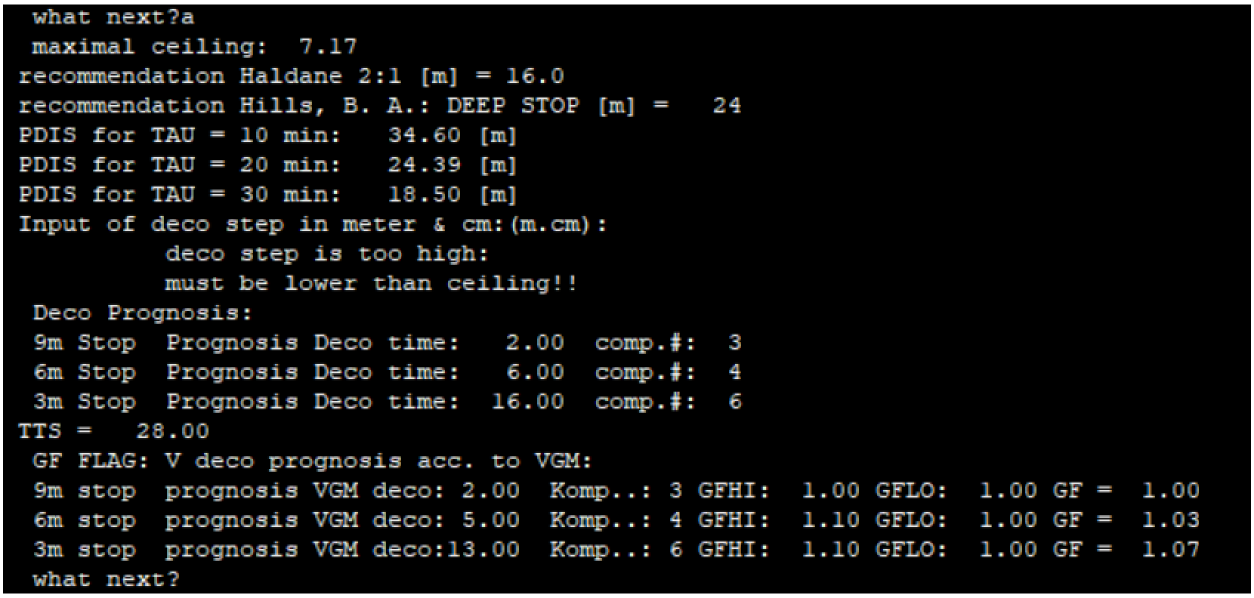
Little experiment with our „standard test dive“ (42 m, 25 min)?
You do that: „d“ „42.“ „25“ then you read the edited N2-file via „nc“, option 3 to get:



```
  what next?nc
 Selection of N2-coefficients matrix:
 1 = Buehlmann, 2 = Hahn, 3 = File, 4 = U.S
 5 = USN: VVAL18, 6 = USN: VVAL76-1
3
  Option: 3  working!
    N2   -   control output!
======================================
  #    TAU      A        B     GFHI   GFLO
  1     4.00  1.2599  0.5050   1.0    1.0
  2     8.00  1.0000  0.6514   1.0    1.0
  3    12.50  0.8618  0.7222   1.0    1.0
  4    18.50  0.7562  0.7825   1.1    1.0
  5    27.00  0.6200  0.8126   1.1    1.0
  6    38.30  0.5043  0.8434   1.1    1.0
  7    54.30  0.4410  0.8693   1.0    1.0
  8    77.00  0.4000  0.8910   1.0    1.0
  9   109.00  0.3750  0.9092   1.0    1.0
 10   146.00  0.3500  0.9222   1.0    1.0
 11   187.00  0.3295  0.9319   1.0    1.0
 12   239.00  0.3065  0.9403   1.0    1.0
 13   305.00  0.2835  0.9477   1.0    1.0
 14   390.00  0.2610  0.9544   1.0    1.0
 15   498.00  0.2480  0.9602   1.0    1.0
 16   635.00  0.2327  0.9653   1.0    1.0
```

39-1: VGM: GF per compartment

and the subsequent deco profile looks like that:



```
  what next?a
  maximal ceiling:   7.17
 recommendation Haldane 2:1 [m] = 16.0
 recommendation Hills, B. A.: DEEP STOP [m] =    24
 PDIS for TAU = 10 min:    34.60 [m]
 PDIS for TAU = 20 min:    24.39 [m]
 PDIS for TAU = 30 min:    18.50 [m]
 Input of deco step in meter & cm:(m.cm):
           deco step is too high:
           must be lower than ceiling!!
  Deco Prognosis:
  9m Stop  Prognosis Deco time:    2.00  comp.#:  3
  6m Stop  Prognosis Deco time:    6.00  comp.#:  4
  3m Stop  Prognosis Deco time:   16.00  comp.#:  6
 TTS =    28.00
  GF FLAG: V deco prognosis acc. to VGM:
  9m stop  prognosis VGM deco: 2.00  Komp..: 3 GFHI:  1.00 GFLO:  1.00 GF =  1.00
  6m stop  prognosis VGM deco: 5.00  Komp..: 4 GFHI:  1.10 GFLO:  1.00 GF =  1.03
  3m stop  prognosis VGM deco:13.00  Komp..: 6 GFHI:  1.10 GFLO:  1.00 GF =  1.07
  what next?
```

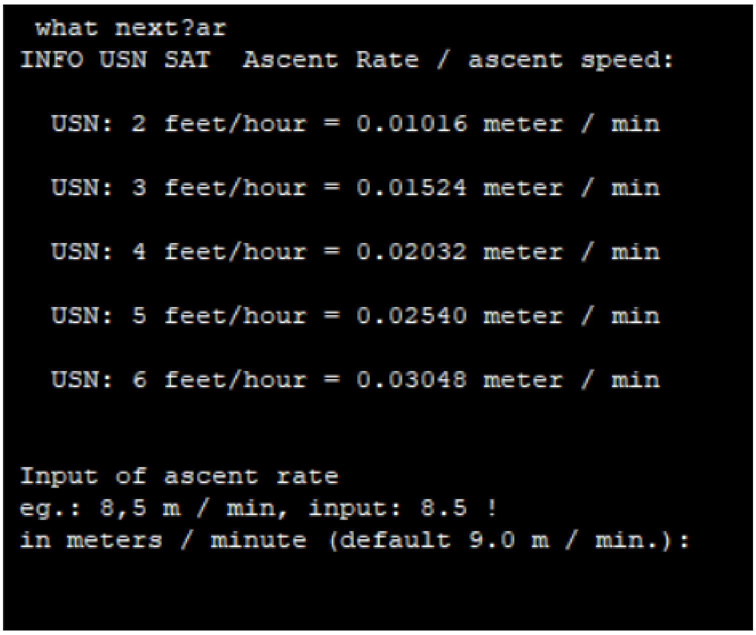
39-2: VGM deco prognosis

You see in this VGM prognosis the lead compartments (3 – 4 – 6), the GFs and the resulting hang-time, reduced from 6 to 5 and 16 to 13: the decrease in TTS is not much, but it shows how you can make the whole thing go nuts …

What was there out in the wild with a „VGM“- label have been deco softwares and dive computers allowing only 3 groups of compartments to be modified: fast, medium and slow. Here you have it granular for all 16 compartments. But anyway: you have now per inertgas and per compartment 4 free parameters (a-, b-, HI, LO; if we set the HT as given, which they are not …) so we end up with 2 * 16 * 4 = 128 parameters. This is by far too much to validate with, say 10,000 TMx-dives or so: just forget it! Actually: all these products, being it a dive computer or a piece of deco software have been disappeared from the market, since long! It is by far too complicated and error prone!!! DIVE features it anyway, but only as a point of reference!

40 „AR“ = ascent rate

From ca. 0.001 (saturation dive) up to 240 (apnea) m / min; the value of 4 m / sec is from the book [129], p. 82. Just fyi, the USN SAT rates are displayed, converted from feet / hour to m / min:



```
 what next?ar
INFO USN SAT  Ascent Rate / ascent speed:

  USN: 2 feet/hour = 0.01016 meter / min

  USN: 3 feet/hour = 0.01524 meter / min

  USN: 4 feet/hour = 0.02032 meter / min

  USN: 5 feet/hour = 0.02540 meter / min

  USN: 6 feet/hour = 0.03048 meter / min


Input of ascent rate
eg.: 8,5 m / min, input: 8.5 !
in meters / minute (default 9.0 m / min.):
```

40-1: AR with INFO block: USN SAT rates

41 „AD“ = accelerated deco

At the MOD with a max. pO_2 of ca. 1.6 atm the EANx 50, 75 and 98 will be kicked in automatically (pure oxygen is calculated with only 98%, because in this mean ‘ole world nothing is really 100 %...)

42 „TA“ = temperature adaption

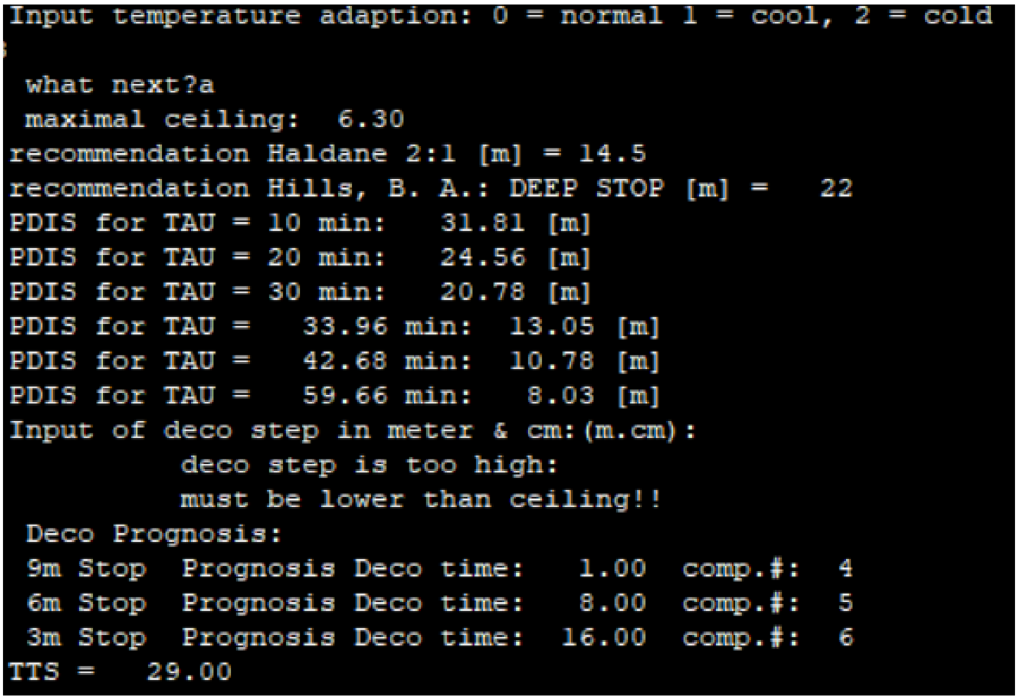
There you could change in 2 steps (1 = cool; 2 = cold) the perfusion of the relevant compartments for muscles and skin. The input of step = 0 sets everything back to normal. Reduced ambient, and then skin temperatures means cooling down and thus less perfusion in the periphery of the body. Less perfusion is equivalent with an increase in HT, but only during de-saturation, that is: ascent.

The original is called „ZH-L 8 ADT“ (ADT = adaptive) from UWATEC. It is basically valid only for 8 compartments und only nitrogen. Thus we have adapted it for 16 compartments, and as well for Helium, but with more built-in conservativism.

One source for this is:

„Accounting for Cold Water Effects in a Decompression Algorithm“, Sergio Angelini in: Lang, M.A. and M.D.J. Sayer (eds.) 2007. Proceedings of the International Polar Diving Workshop. Svalbard, March 15-21, 2007. Smithsonian Institution, Washington, DC. 213 pp. S. 55 – 62)

A a little exercise? Oh yes: we do a trivial TEC dive (40 m, 20 min, Tmx 20/40/40). By the end of the bottom time the diver feels cold („ta“ „2“), then the ascent to a deep stop: „a“ „20.“ And we see already the increase in the TTS from 22 min to 29 min very clearly; if you check your P(DCS) you may see the significant increase from ca. 0.10 to ca. 0.13:



```
Input temperature adaption: 0 = normal 1 = cool, 2 = cold
:

 what next?a
 maximal ceiling:  6.30
recommendation Haldane 2:1 [m] = 14.5
recommendation Hills, B. A.: DEEP STOP [m] =   22
PDIS for TAU = 10 min:   31.81 [m]
PDIS for TAU = 20 min:   24.56 [m]
PDIS for TAU = 30 min:   20.78 [m]
PDIS for TAU =   33.96 min:  13.05 [m]
PDIS for TAU =   42.68 min:  10.78 [m]
PDIS for TAU =   59.66 min:   8.03 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
 9m Stop  Prognosis Deco time:   1.00  comp.#:  4
 6m Stop  Prognosis Deco time:   8.00  comp.#:  5
 3m Stop  Prognosis Deco time:  16.00  comp.#:  6
TTS =   29.00
```

42-1: deco prognosis after temperature adaption

43 „MX“ = matrix with the balanced coefficients

Diving with mix gas means that the perfusion-constants (in ZH-L parlance the a-, b- coefficients and the HT) have to be mass-balanced with the according tissue-(compartment) saturation for each inertgas. This goes like that, paradigm here with the a-coefficient:

$$a_{\text{mix gas}} = (a_{N2} * p_{\text{tissue, N2}} + a_{He} * p_{\text{tissue, He}}) / (p_{\text{tissue, N2}} + p_{\text{tissue, He}})$$

Sources are: Buehlmann, 2002 [65], p. 119 and [54], p. 86.

So only the compartment number is here to stay: everything else is now weighted in relation to the sum of the inertgaspartialpressures of Nitrogen + Helium. The „mx“ helps you to not loose track of what is going on at run-time, especially if you changed already the coefficients as such („nc“, „hc“).

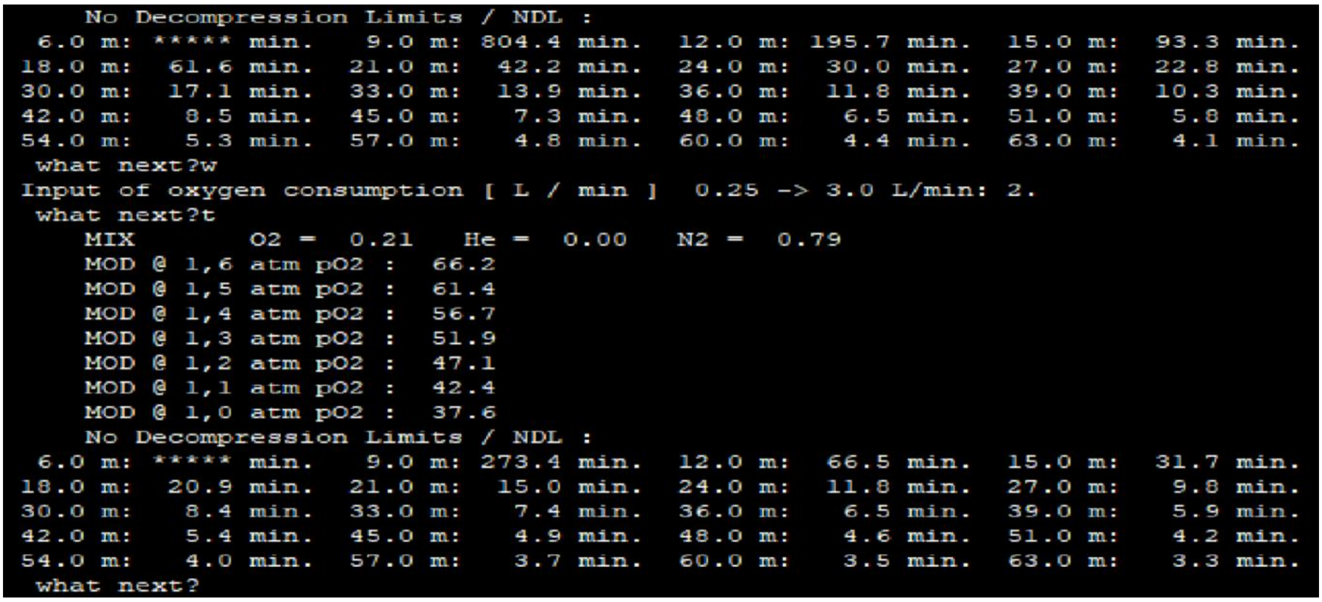
44 „LAT“ = latency during a mix change

During a change in the breathing mix, for eg. to a „fat“ EANx or TMx at the deco stops, the usual mixgas computers or deco software calculates with the increased pO_2 instantaneously. But due to a finite transport capacity of the lung and a heterogeneous ventilation/perfusion ration and the so-called „working“ alveoli and capillaries (in contrast to the „sleeping“ ones), it takes time until the higher inspired pO_2 comes into effect. The adaption of the arterial pO_2 to the alveolary is called „latency“. It is obviously dependant on: vital capacity, breathing frequency and workload and takes between 3 to 6 min. With the command „lat“ you toggle this effect on or off; via „z“ you check this. One of the sources for it is: [102], p. 167.

45 „W“ = workload

Workload = physical workload, and thus the oxygen consumption (VO_2).
VO_2 could be adapted from 0.25 (rest) to 3 L/min (olympic champion or in a tunnel resp. at caisson-work). The higher workload calls for more oxygen, this triggers a higher perfusion. Thus the HT in certain compartments is decreased, which, in turn rises the inertgas saturation. Thus you could see NDLs going down or hang-times going up; if you are in deco, don’t forget to set the workload down again.

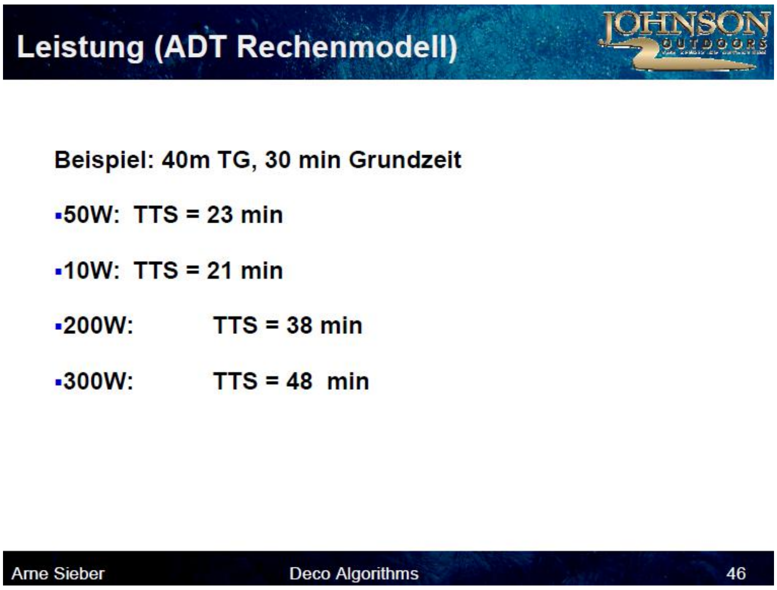
The sources for this are:
- ➔ Dick APK, Vann RD, Mebane GY, Feezor MD. Decompression induced nitrogen elimination. Undersea Biomed. Res. 1984; 11(4): 369 – 380;
- ➔ Doolette DJ, Gerth WA, Gault KA. Probabilistic Decompression Models With Work-Induced Changes In Compartment Gas Kinetic Time Constants. Navy Experimental Diving Unit, Panama City, FL, USA; in: UHMS Annual Scientific Meeting, St. Pete Beach, Florida, June 3-5, 2010, Session A6



```
     No Decompression Limits / NDL :
  6.0 m: ***** min.    9.0 m: 804.4 min.   12.0 m: 195.7 min.   15.0 m:   93.3 min.
 18.0 m:   61.6 min.   21.0 m:   42.2 min.   24.0 m:   30.0 min.   27.0 m:   22.8 min.
 30.0 m:   17.1 min.   33.0 m:   13.9 min.   36.0 m:   11.8 min.   39.0 m:   10.3 min.
 42.0 m:    8.5 min.   45.0 m:    7.3 min.   48.0 m:    6.5 min.   51.0 m:    5.8 min.
 54.0 m:    5.3 min.   57.0 m:    4.8 min.   60.0 m:    4.4 min.   63.0 m:    4.1 min.
  what next?w
 Input of oxygen consumption [ L / min ]  0.25 -> 3.0 L/min: 2.
  what next?t
     MIX        O2 =   0.21    He =   0.00    N2 =   0.79
     MOD @ 1,6 atm pO2 :   66.2
     MOD @ 1,5 atm pO2 :   61.4
     MOD @ 1,4 atm pO2 :   56.7
     MOD @ 1,3 atm pO2 :   51.9
     MOD @ 1,2 atm pO2 :   47.1
     MOD @ 1,1 atm pO2 :   42.4
     MOD @ 1,0 atm pO2 :   37.6
     No Decompression Limits / NDL :
  6.0 m: ***** min.    9.0 m: 273.4 min.   12.0 m:   66.5 min.   15.0 m:   31.7 min.
 18.0 m:   20.9 min.   21.0 m:   15.0 min.   24.0 m:   11.8 min.   27.0 m:    9.8 min.
 30.0 m:    8.4 min.   33.0 m:    7.4 min.   36.0 m:    6.5 min.   39.0 m:    5.9 min.
 42.0 m:    5.4 min.   45.0 m:    4.9 min.   48.0 m:    4.6 min.   51.0 m:    4.2 min.
 54.0 m:    4.0 min.   57.0 m:    3.7 min.   60.0 m:    3.5 min.   63.0 m:    3.3 min.
  what next?
```

45-1: O_2-consumption / workload ("w")

From Arne Sieber (Seabear-Technologies, and the then head of R&D at Uwatec) i recieved the following chart. It reads: workload (ADT algorithm) for a dive to 40 m, 30 min bottom time:



Leistung (ADT Rechenmodell)

Beispiel: 40m TG, 30 min Grundzeit

- **50W: TTS = 23 min**
- **10W: TTS = 21 min**
- **200W: TTS = 38 min**
- **300W: TTS = 48 min**

Arne Sieber Deco Algorithms 46

45-2: workload & TTS (source: Arne Sieber, UWATEC)

This matches approximately with DIVE and an adaption due to the ZH-86 table values:
39 m / 25 min; TTS = 21

39 m / 25 min	**VO_2 [l/min]**	**TTS [min]**
	.25	21
	.5	27
	1.0	38
	1.5	45
	2.0	51

Table 4: VO2 & TTS

46 „O2“ = the O_2 HT

With this command you can manipulate your oxygen-clock during SI, i.e. the half-life time (HT) of Oxygen and thus the ox-tox dose (%CNS) versus time. Unce upon the time it was agreed to be 90 min, now it is 120 min since long.

But the great master himself (Bob Hamilton, may he rest in peace) once said: „There is no experimental basis on this!“. And as the NOAA since ca. 2013 puts it in the 5th. edition of her diving manual ([149] p. 4-27): „ … **120 min halftime … consistent NOAA practice** …“, we have implemented this little parameter so that you could compare the %CNS doses with other deco programs. The deco prognosis as such is clearly not affected.

The source for the witty statement of Bob is: Proceedings of 49th UHMS workshop, 2001, p. 70.

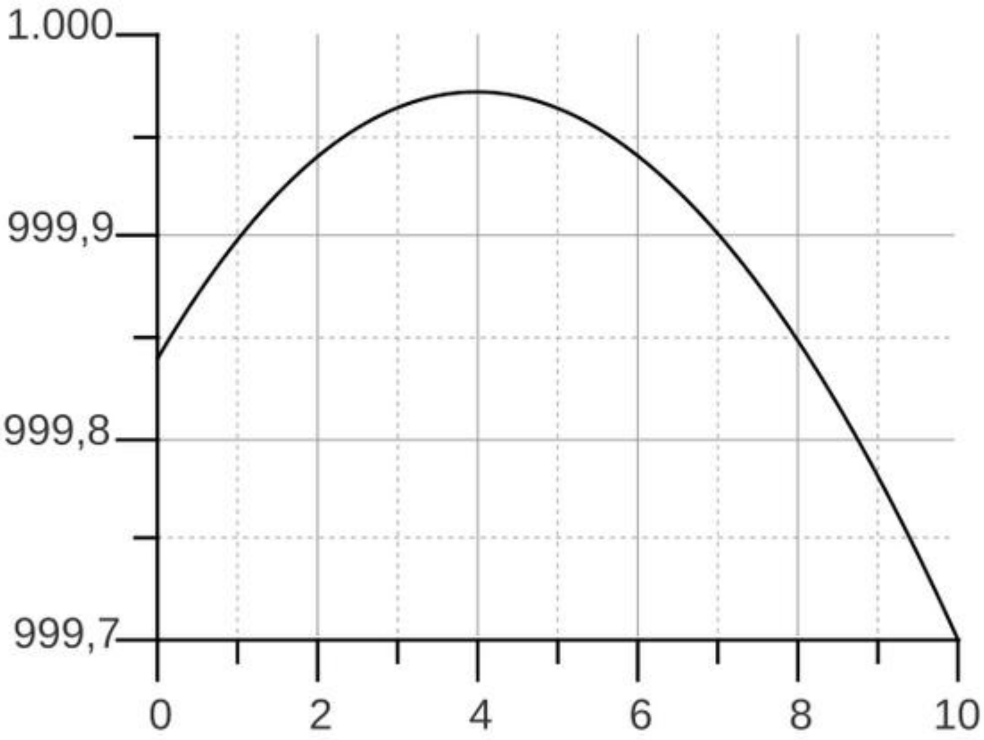
47 Water, water, water…. (DI & TE)

With these 2 commands you could mirror various ambient situations. These may play no role for trivial rec/TEC dives, but for a sat-dive in the North Sea at 150 m its a competely different game!

DI (from „**D**ens**I**ty") could coarsly adapt the specific density of fresh- and sea water, it defaults to fresh water at 20 °C. A lot of tables or dive computers are using any cryptic mean-value; for eg. the ZH-86 uses 1.02 kg / L.

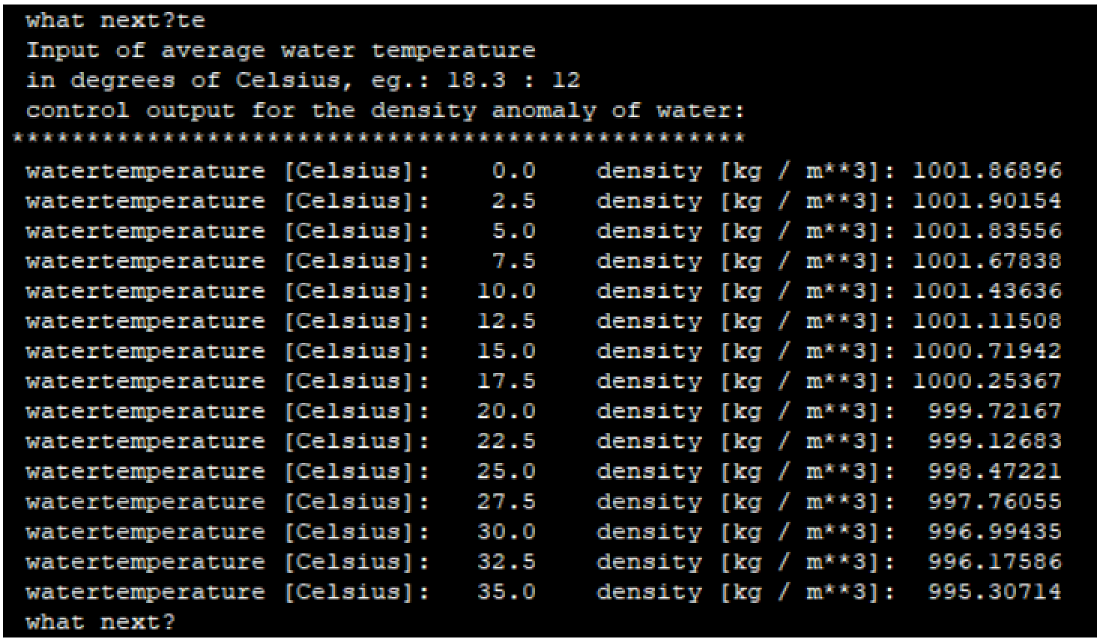
„Real" sea water has an approx. 3 % higher density, which changes with: temperature, salinity, and geographical location; i.e.: ca. 1.025 – 1.03 kg / L.

TE (from „**TE**mperature") offers a fine tuning of the ambient water temperature and thus as well the density. The H_2O molecules in the fluid state have something peculiar: it is the density anomaly, i.e.: the negative thermal expansion, at ca. 4° C:



47-1: the density anomaly of water: density (y-axis) vs. temp. (x-axis)

With a „TE" input unequal to 20° C you see this as a little table:



```
 what next?te
 Input of average water temperature
 in degrees of Celsius, eg.: 18.3 : 12
 control output for the density anomaly of water:
*************************************************
 watertemperature [Celsius]:    0.0    density [kg / m**3]: 1001.86896
 watertemperature [Celsius]:    2.5    density [kg / m**3]: 1001.90154
 watertemperature [Celsius]:    5.0    density [kg / m**3]: 1001.83556
 watertemperature [Celsius]:    7.5    density [kg / m**3]: 1001.67838
 watertemperature [Celsius]:   10.0    density [kg / m**3]: 1001.43636
 watertemperature [Celsius]:   12.5    density [kg / m**3]: 1001.11508
 watertemperature [Celsius]:   15.0    density [kg / m**3]: 1000.71942
 watertemperature [Celsius]:   17.5    density [kg / m**3]: 1000.25367
 watertemperature [Celsius]:   20.0    density [kg / m**3]:  999.72167
 watertemperature [Celsius]:   22.5    density [kg / m**3]:  999.12683
 watertemperature [Celsius]:   25.0    density [kg / m**3]:  998.47221
 watertemperature [Celsius]:   27.5    density [kg / m**3]:  997.76055
 watertemperature [Celsius]:   30.0    density [kg / m**3]:  996.99435
 watertemperature [Celsius]:   32.5    density [kg / m**3]:  996.17586
 watertemperature [Celsius]:   35.0    density [kg / m**3]:  995.30714
 what next?
```

47-2: „TE“ and the density anomaly of water

You check always the topical status of both variables via „z“.

48 “PDCS” = Probability of Decompression Sickness

Here we have implemented 5 very different, orderly published methods for a coarse estimate of a P(DCS):

Method I:	Southerland, David Graham: PHD Thesis, 1992, p. 78 & p. 9
Method II:	PME Model, we have expanded it to 6 compartments for TEC diving w. Helium
Method III:	Volume VI, „Statistically Based Decompression Tables“, p.5 & p. 55; we have simplified the risk-integral
Method IV:	NEDU Report 12/2004: TR 04-41, p.8 & p. 11, no adaptions by us, it uses the TTS
Method V:	NEDU Report TR 09-03 1/2009, p. 9 & 11, as well no adaption, it is very sensitive on the ascent rate

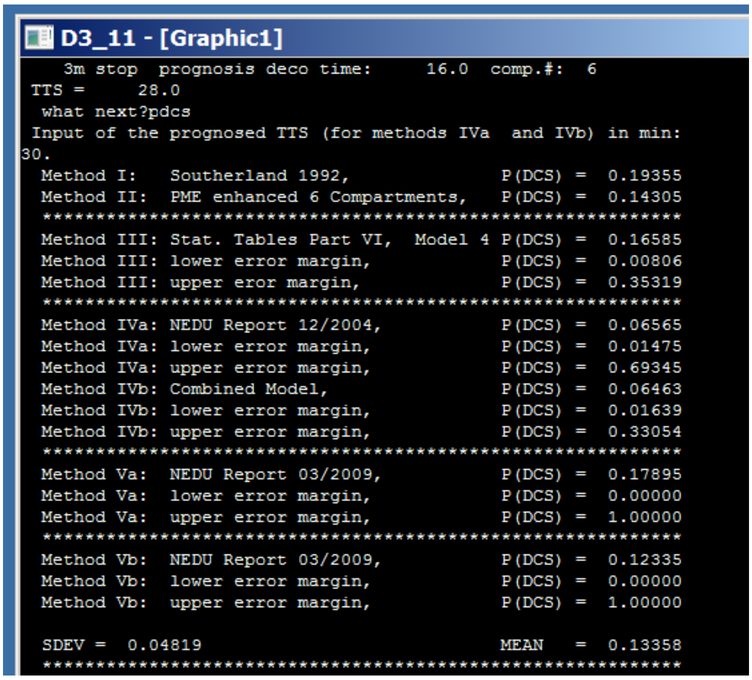
A compilation of all these sources and a little bit of snappy prose you will find in a three-article series for the TDM:

Tech Diving Mag, Issue 14 / 2014:
Yet Another Benchmark, Part III: on the probability of getting decompression sickness (P(DCS))
TDM , Volume 14 / 2014, p. 3 – 11
http://www.divetable.eu/TDM/TDM_Issue014.pdf

Tech Diving Mag, Issue 12 / 2013:
Yet Another Benchmark, Part II: the HELIOX DIVE
TDM , Volume 12 / 2013, p. 3 – 9
http://www.divetable.eu/TDM/TDM_Issue012.pdf

Tech Diving Mag, Issue 11 / 2013:
Yet Another Benchmark, Part I: the AIR DIVE
TDM ,Volume 11 / 2013, p. 3 – 10
http://www.divetable.eu/TDM/TDM_Issue011.pdf

For our „standard test dive“ (42 m, 25 min) we have at the deep stop stage the following, still planning with 30 min TTS:

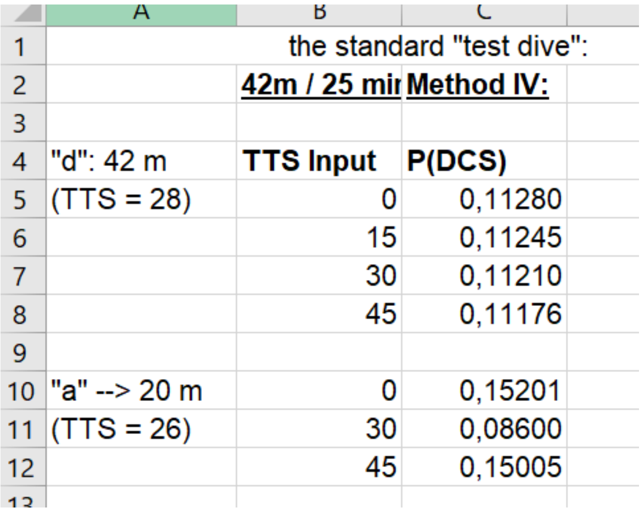


```
    3m stop  prognosis deco time:     16.0  comp.#:  6
 TTS =      28.0
  what next?pdcs
 Input of the prognosed TTS (for methods IVa  and IVb) in min:
30.
  Method I:   Southerland 1992,              P(DCS) =  0.19355
  Method II:  PME enhanced 6 Compartments,   P(DCS) =  0.14305
  ************************************************************
  Method III: Stat. Tables Part VI,  Model 4 P(DCS) =  0.16585
  Method III: lower error margin,            P(DCS) =  0.00806
  Method III: upper eror margin,             P(DCS) =  0.35319
  ************************************************************
  Method IVa: NEDU Report 12/2004,           P(DCS) =  0.06565
  Method IVa: lower error margin,            P(DCS) =  0.01475
  Method IVa: upper error margin,            P(DCS) =  0.69345
  Method IVb: Combined Model,                P(DCS) =  0.06463
  Method IVb: lower error margin,            P(DCS) =  0.01639
  Method IVb: upper error margin,            P(DCS) =  0.33054
  ************************************************************
  Method Va:  NEDU Report 03/2009,           P(DCS) =  0.17895
  Method Va:  lower error margin,            P(DCS) =  0.00000
  Method Va:  upper error margin,            P(DCS) =  1.00000
  ************************************************************
  Method Vb:  NEDU Report 03/2009,           P(DCS) =  0.12335
  Method Vb:  lower error margin,            P(DCS) =  0.00000
  Method Vb:  upper error margin,            P(DCS) =  1.00000

  SDEV =  0.04819                            MEAN   =  0.13358
  ************************************************************
```

48-1: P(DCS) at a deep stop from 42 m / 25 min

Just for the fun of it there is the standard deviation (left: SDEV) and as well the arithmetic (unweighted-) mean (right: MEAN) of all these five „measurements“. Exploiting the published parameter variations we give as well the upper und the lower error margins.

If you play around with the TTS for a fixed profile you may see clearly, especially with the method IV, that there are sub-optimal hang-times. Blindly increasing deco stops may be counter-productive by increasing the P(DCS):



	A	B	C
1		the standard "test dive":	
2		**42m / 25 mi**	**Method IV:**
3			
4	"d": 42 m	**TTS Input**	**P(DCS)**
5	(TTS = 28)	0	0,11280
6		15	0,11245
7		30	0,11210
8		45	0,11176
9			
10	"a" --> 20 m	0	0,15201
11	(TTS = 26)	30	0,08600
12		45	0,15005

Table 5: P(DCS) of method IV in dependency of the TTS

Attention:
All these P(DCS) algorithms are using parameters, found by fitting to tenthousands of well-documented dives. These dives are called „calibration dives“ and follow certain boundary conditions, for eg. only EAN, only saturation dives, only one level (box profiles) and the like. So your dive from DIVE should not lay outside the scope of these calibration dives!

Normally these calibration dives have been run under:
→ **physical workload** (75 – 150 W) and in a
→ relatively **cool water**. As well the already previously mentioned method of the:
→ **instantaneous descent** puts the calculated P(DCS) values in a much higher range than for your rec-dives. And, as well, the pure mathematical method as such, the so called „Fit“, is delivering
→ **higher values**, basically!

If you do not like this maze of figures from the „pdcs“ command, then use „%p“ for a more intuitive picture.

An overview and a little commented list on the most important documents to this topic is there:

P(DCS) - on the statistical nature of decompression sickness; a short literature review with limited scope. (14.04.2024)

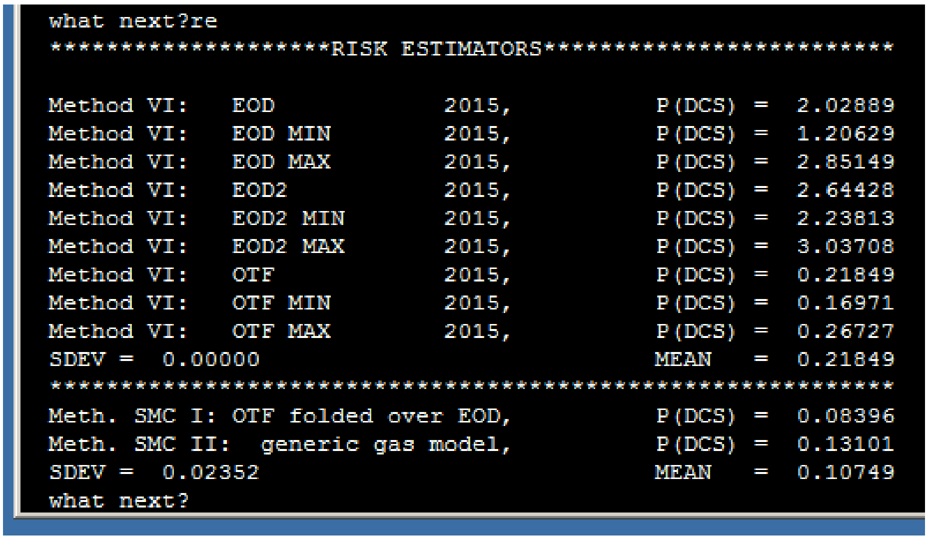
https://dx.doi.org/10.13140/RG.2.2.33711.75685

49 Update with DIVE V 3_02 (per 07/2018): „re“

The PDCS routines have been expanded a little bit with two more, so-called „risk estimators“, that is „best estimates“! From Version 3_02 (07/2018) on we have 2 more algorithms in the additional method VI with the variants:

→ **EOD** / end-of-dive (at the end of the dive!)
→ **OTF** / on-the-fly (during the dive!)

displayed with the appropriate MIN (minimal) and MAX (maximal) -values. Here our standard test dive, the demarcation to the „proofed“ methods is done via a lines of little stars. As well there is a separate calculation of the statistical assessment, and this only when the values are *> 0.0 AND < 1.0*:



```
what next?re
*******************RISK ESTIMATORS************************

Method VI:   EOD            2015,          P(DCS) =  2.02889
Method VI:   EOD MIN        2015,          P(DCS) =  1.20629
Method VI:   EOD MAX        2015,          P(DCS) =  2.85149
Method VI:   EOD2           2015,          P(DCS) =  2.64428
Method VI:   EOD2 MIN       2015,          P(DCS) =  2.23813
Method VI:   EOD2 MAX       2015,          P(DCS) =  3.03708
Method VI:   OTF            2015,          P(DCS) =  0.21849
Method VI:   OTF MIN        2015,          P(DCS) =  0.16971
Method VI:   OTF MAX        2015,          P(DCS) =  0.26727
SDEV =   0.00000                           MEAN   =  0.21849
************************************************************
Meth. SMC I: OTF folded over EOD,          P(DCS) =  0.08396
Meth. SMC II:  generic gas model,          P(DCS) =  0.13101
SDEV =   0.02352                           MEAN   =  0.10749
what next?
```

49-1: PDCS, from Version 3_11 with EOD and OTF

Why? *Because these particular EOD / OTF risk estimators do not always follow the usual expectations for a standard risk integral, that is: 0 < P(DCS) < 1*! Thus the following „caveat“:

→ these estimators are only valid for the connected dive scenarios!

→ i.e.: EOD (= **end-of-dive**) makes only sense at the surface, at the end of the dive

→ i.e.: OTF (= **on-the-fly**) makes only sense during ascent, by the end of the bottom time

→ the calibration data base incorporates only a few RGBM profiles (only 3,569 with 26 DCS cases as per Bruce Wienke in 2015). The statistical validation against the proved and tested USN-methods is thus more than questionable!

→ as well the entries in the RGBM-data bank are not always digital dive profiles from dive computers, very much unlike DAN DSG or the USN!
(Sources:

- ➔ for DAN DSG: https://www.diversafetyguardian.org/ ; and
- ➔ for the USN: http://divingresearch.scripts.mit.edu/militarydivingdata/)

but, in stark contrast, according to BRW: „ …underwater notes from seasoned divers …“ (sic!). That is, in plaintext, any smearing on wet-notes.

Thus we have tried to iron out the flaws in BRWs papers and have contributed two new methods:

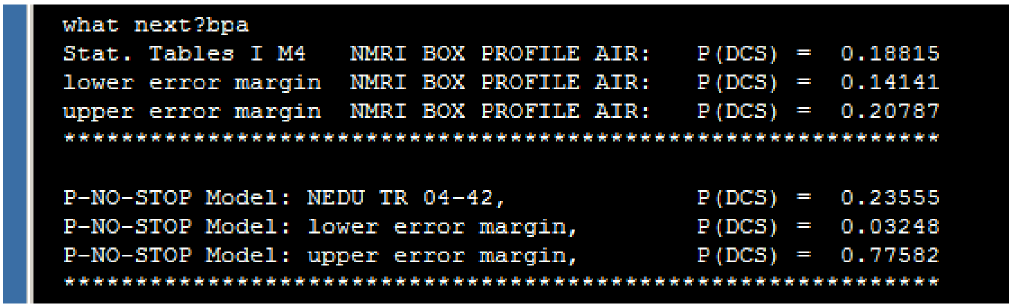
SMC method I: „OTF folded over EOD“, which converges very rapidly to:
Southerland (I) resp. NEDU 2009 (V); and:
SMC Method II: in where we have adapted a generic „gas content model“.

So, to quote our boss: „RGBM is nebech!“ © ALBI 2021 (for an explanation of nebech, pls. cf. Ulam, S. (1991) Adventures of a Mathematician, on pages 194 – 195 …)

50 Box Profile on Air: „BPA“

This is the method from the Naval Medical Research Institute (NMRI), the so-called „Model 4“, source: Statistically Based Decompression Tables, I; p. 5, 29 & 31.

It uses only 5 parameters: 2 compartments with Gain Factors and a threshold value. It works for simple box profiles on air. The used risk-integral is adapted for box-profiles: if the profile consists of more steps, the risk-values are added (top part):



```
what next?bpa
Stat. Tables I M4   NMRI BOX PROFILE AIR:   P(DCS) =  0.18815
lower error margin  NMRI BOX PROFILE AIR:   P(DCS) =  0.14141
upper error margin  NMRI BOX PROFILE AIR:   P(DCS) =  0.20787
*************************************************************

P-NO-STOP Model: NEDU TR 04-42,             P(DCS) =  0.23555
P-NO-STOP Model: lower error margin,        P(DCS) =  0.03248
P-NO-STOP Model: upper error margin,        P(DCS) =  0.77582
*************************************************************
```

In the lower part we find the so-called „P-NO-STOP Model“ (source: NEDU TR 04-42, December 2004: Probability of Decompression Sickness in No-Stop AIR DIVING) with the parameters on p.14 and the LOG-IT formula from p. 8.

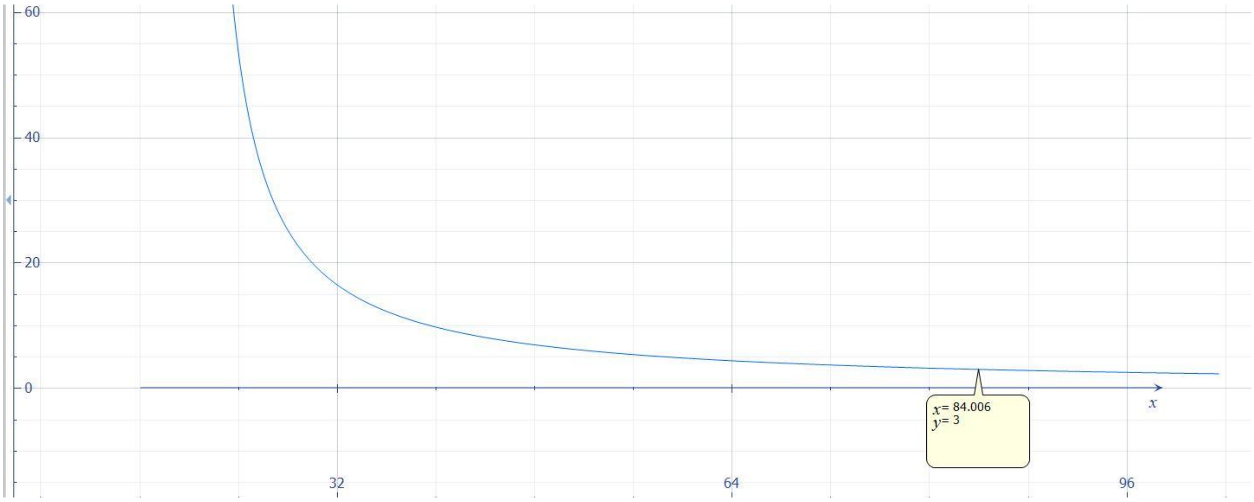
The calculation of the respective lower & upper error margins is done with the so-called „ASE“ (asymptotic standard error).

51 The COMEX procedure: „CP“

The famous french company COMEX (https://comex.fr/) had had once developped a deco procedure out of a couple of hundred SAT dives. Since this procedure does NOT use any compartments or half-times, we have it adapted for bounce dives on air. There is only one free parameter, the greek lambda (**λ**).

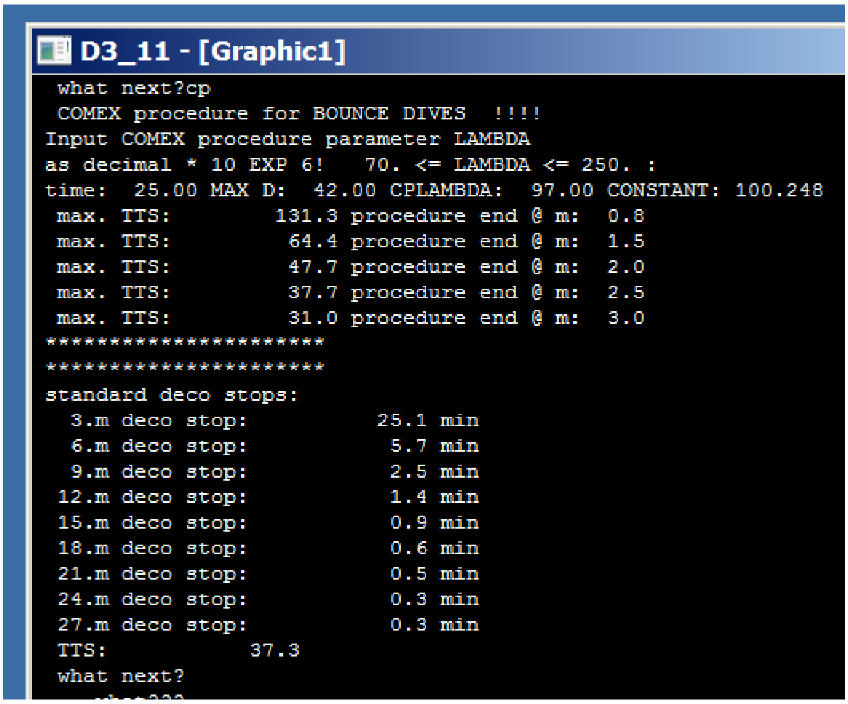
For heliox, real SAT, cold water, high pO2 or high workload, this lambda (**λ**) has to be adapted separately.

Since the procedure looks always the same as a hyperbola (pls. cf. the picture below, from „MS Mathematics“), just with changed bottom depths (y-axis) and times (x-axis), so there is no graphical output in DIVE, but the pure numbers:



51-1: Example of a COMEX procedure for a BOUNCE dive

For our, now famous, test-dive (42.0 m, 25.0 min) it looks like that:



```
 what next?cp
 COMEX procedure for BOUNCE DIVES  !!!!
Input COMEX procedure parameter LAMBDA
as decimal * 10 EXP 6!   70. <= LAMBDA <= 250. :
time:  25.00 MAX D:  42.00 CPLAMBDA:  97.00 CONSTANT: 100.248
 max. TTS:         131.3 procedure end @ m:  0.8
 max. TTS:          64.4 procedure end @ m:  1.5
 max. TTS:          47.7 procedure end @ m:  2.0
 max. TTS:          37.7 procedure end @ m:  2.5
 max. TTS:          31.0 procedure end @ m:  3.0
**********************
**********************
standard deco stops:
  3.m deco stop:          25.1 min
  6.m deco stop:           5.7 min
  9.m deco stop:           2.5 min
 12.m deco stop:           1.4 min
 15.m deco stop:           0.9 min
 18.m deco stop:           0.6 min
 21.m deco stop:           0.5 min
 24.m deco stop:           0.3 min
 27.m deco stop:           0.3 min
 TTS:           37.3
 what next?
```

51-2: COMEX procedure for 42 m / 25 min.

Depending on aggressivity, that is, with ending at 3, 2 or 1 m, the stop times become exponentially longer. Breaking out @ 3, the TTS is comparable to standard dive tables.

The sources of the COMEX wisdom is there:

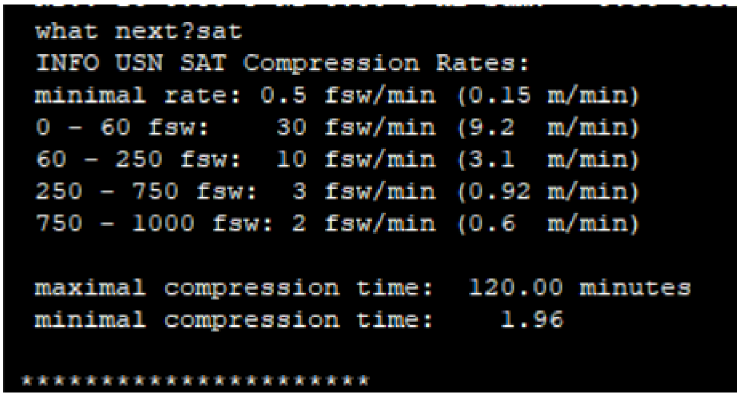
From their website: www.comex.fr
And, as well:
- CBM-D-19-00911, formula 62 on p. 20
- and, from Bernard Gardette himself:
- THEORIE GENERALE UNIFIEE DE LA DECOMPRESSION; Directeur Scientifique COMEX, November 2009, BG/sc-060/09

52 The MT92 / COMEX, N-15 and USN procedures for saturation dives: „SAT“

For the deep & long Heliox dives with decompression on oxygen, the USN developped & tested procedures. Thus they do not need any but one half-time, that is: the longest one of all compartments. The procedure is therefore just a rule-of-threes; the official sources being the famous USN diving manuals and others:

- USN old: 1991, p. 12-42
- USN new: 2018, Table 13-9, p. 686
- the MT92 / COMEX tables from France
- the NORMAM-15 procedures from Brazil

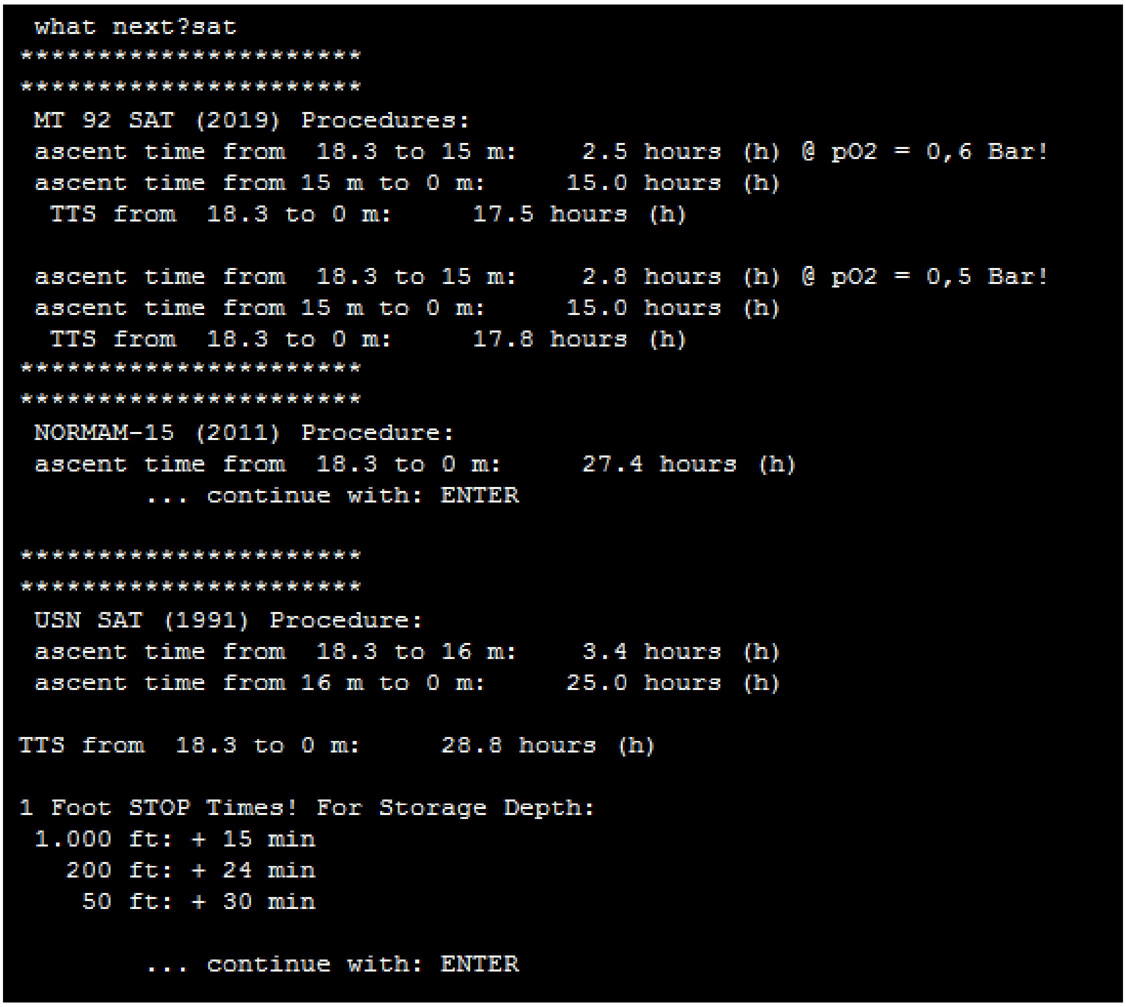
By inwoking the „sat“ dialogue you will be greeted with another info bloc with USN info, converted to SI-units:



```
 what next?sat
 INFO USN SAT Compression Rates:
 minimal rate: 0.5 fsw/min (0.15 m/min)
 0 - 60 fsw:    30 fsw/min (9.2  m/min)
 60 - 250 fsw:  10 fsw/min (3.1  m/min)
 250 - 750 fsw:  3 fsw/min (0.92 m/min)
 750 - 1000 fsw: 2 fsw/min (0.6  m/min)

 maximal compression time:  120.00 minutes
 minimal compression time:    1.96

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

52-1: USN SAT compression rates

You use it for bottom times substantially longer than 600 min., say, for example, you use the „AQUARIUS“ habitat @ 60 feet in the gulf of florida:



```
 what next?sat
**********************
**********************
 MT 92 SAT (2019) Procedures:
 ascent time from  18.3 to 15 m:    2.5 hours (h) @ pO2 = 0,6 Bar!
 ascent time from 15 m to 0 m:     15.0 hours (h)
  TTS from  18.3 to 0 m:     17.5 hours (h)

 ascent time from  18.3 to 15 m:    2.8 hours (h) @ pO2 = 0,5 Bar!
 ascent time from 15 m to 0 m:     15.0 hours (h)
  TTS from  18.3 to 0 m:     17.8 hours (h)
**********************
**********************
 NORMAM-15 (2011) Procedure:
 ascent time from  18.3 to 0 m:     27.4 hours (h)
        ... continue with: ENTER

**********************
**********************
 USN SAT (1991) Procedure:
 ascent time from  18.3 to 16 m:    3.4 hours (h)
 ascent time from 16 m to 0 m:     25.0 hours (h)

TTS from  18.3 to 0 m:     28.8 hours (h)

1 Foot STOP Times! For Storage Depth:
 1.000 ft: + 15 min
   200 ft: + 24 min
    50 ft: + 30 min

        ... continue with: ENTER
```

52-1: USN SAT procedures from 1991 in comparison to MT92 / COMEX & N-15

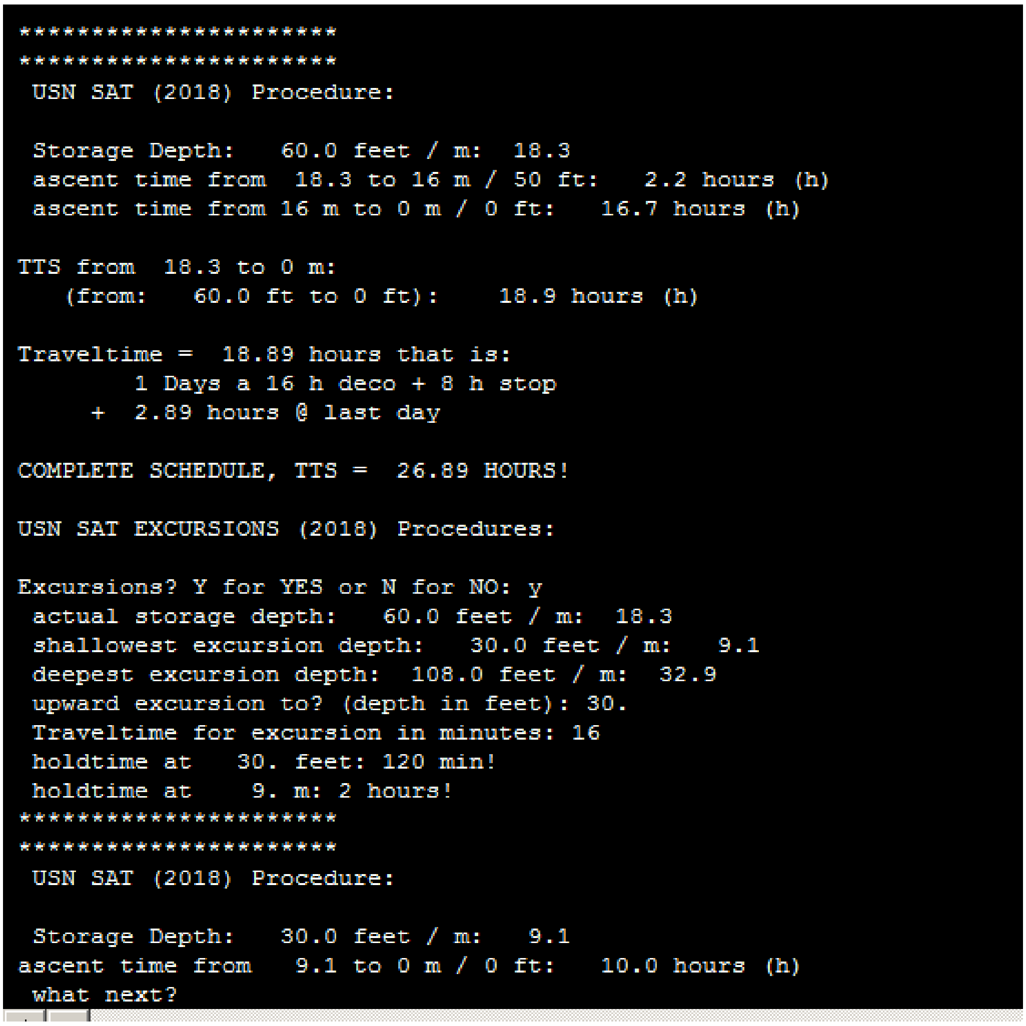
As the new (2018) USN manual is exclusively in imperial units, the excursions dialogue outputs depths in feet and accepts feet (the geometrical diving depth, a length).

A lot of information in the USN manual is in fsw, feet of sea water, however. This is a pressure. In order to help you with the conversion factors, the „TE“ or „DI“ dialogues display this now.

A summary on the use of pressure units you will find there:

Miri Rosenblat, TAU; Nurit Vered, Technion Haifa; Albi Salm, SubMarineConsulting (02.02.2023) The diving medical detectives: when diving medicine books are completely wrong, Part V: On pressure units, DOI: 10.13140/RG.2.2.31827.45600

If you key in „Y“ for an excursion, you will be guided through the possible values.
The the pure travel time for an upward excursion and a hold-time of 2 hrs is diplayed,
and then the final TTS from the new storage depth to surface:

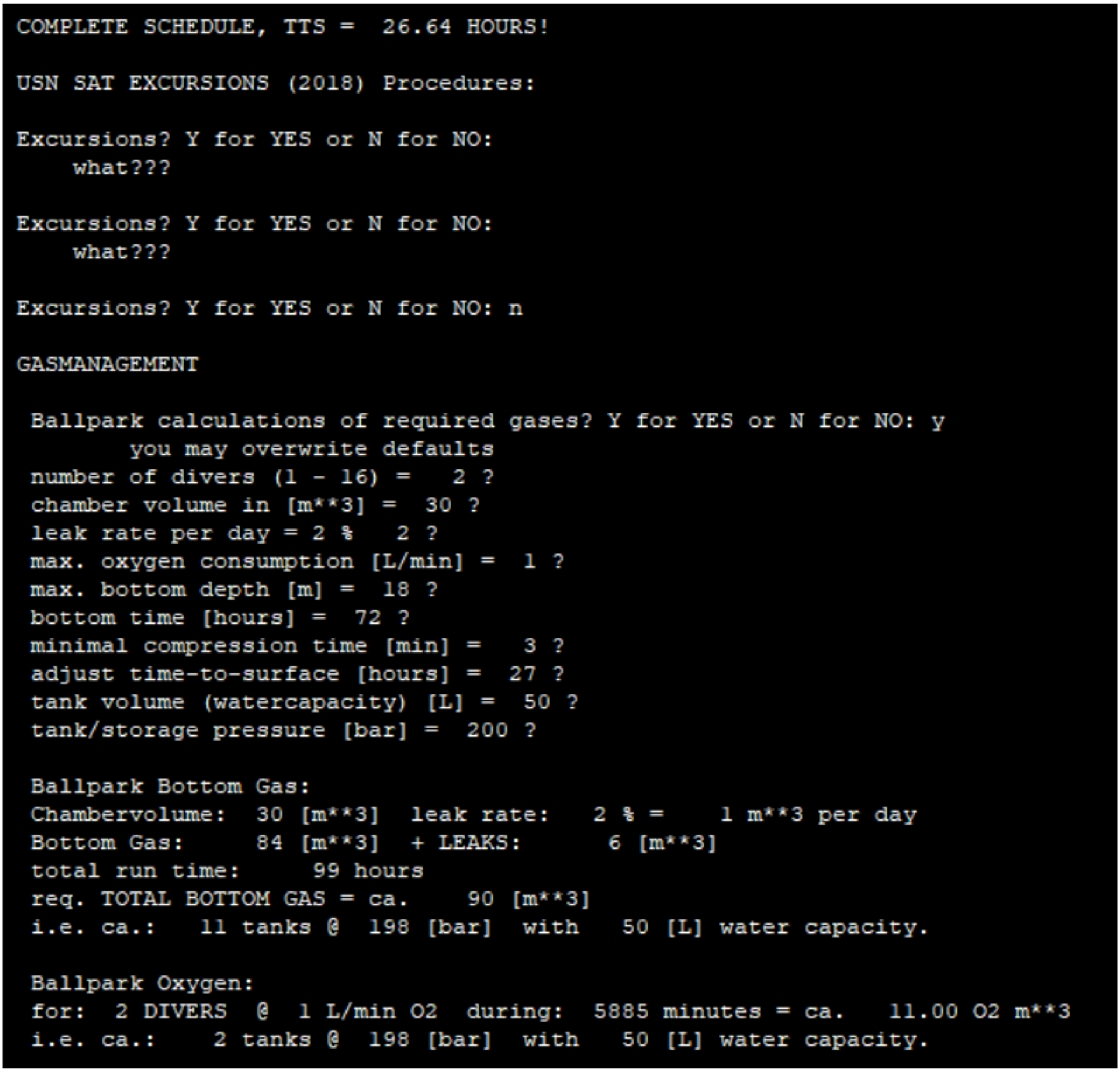


```
**********************
**********************
 USN SAT (2018) Procedure:

 Storage Depth:   60.0 feet / m:  18.3
 ascent time from  18.3 to 16 m / 50 ft:   2.2 hours (h)
 ascent time from 16 m to 0 m / 0 ft:   16.7 hours (h)

TTS from  18.3 to 0 m:
   (from:   60.0 ft to 0 ft):    18.9 hours (h)

Traveltime =  18.89 hours that is:
        1 Days a 16 h deco + 8 h stop
     +  2.89 hours @ last day

COMPLETE SCHEDULE, TTS =  26.89 HOURS!

USN SAT EXCURSIONS (2018) Procedures:

Excursions? Y for YES or N for NO: y
 actual storage depth:   60.0 feet / m:  18.3
 shallowest excursion depth:   30.0 feet / m:   9.1
 deepest excursion depth:  108.0 feet / m:  32.9
 upward excursion to? (depth in feet): 30.
 Traveltime for excursion in minutes: 16
 holdtime at   30. feet: 120 min!
 holdtime at    9. m: 2 hours!
**********************
**********************
 USN SAT (2018) Procedure:

 Storage Depth:   30.0 feet / m:   9.1
ascent time from   9.1 to 0 m / 0 ft:   10.0 hours (h)
 what next?
```

52-2: USN SAT procedures from 2018 with excursions

The required breaks for 8 h occur during night-time, always if the travel time exceeds 16 h: there should be no decompression, while you are sleeping …

After that, the gas management tool for a *ballpark* calculation of the required bottom- and O_2 gases will ask you some questions. If you do not want to use it, just a simple „N“ will do …



```
COMPLETE SCHEDULE, TTS =  26.64 HOURS!

USN SAT EXCURSIONS (2018) Procedures:

Excursions? Y for YES or N for NO:
    what???

Excursions? Y for YES or N for NO:
    what???

Excursions? Y for YES or N for NO: n

GASMANAGEMENT

 Ballpark calculations of required gases? Y for YES or N for NO: y
        you may overwrite defaults
 number of divers (1 - 16) =   2 ?
 chamber volume in [m**3] =  30 ?
 leak rate per day = 2 %   2 ?
 max. oxygen consumption [L/min] =  1 ?
 max. bottom depth [m] =  18 ?
 bottom time [hours] =  72 ?
 minimal compression time [min] =   3 ?
 adjust time-to-surface [hours] =  27 ?
 tank volume (watercapacity) [L] =  50 ?
 tank/storage pressure [bar] =  200 ?

 Ballpark Bottom Gas:
 Chambervolume:  30 [m**3]  leak rate:   2 % =    1 m**3 per day
 Bottom Gas:     84 [m**3]  + LEAKS:      6 [m**3]
 total run time:     99 hours
 req. TOTAL BOTTOM GAS = ca.    90 [m**3]
 i.e. ca.:   11 tanks @  198 [bar]  with   50 [L] water capacity.

 Ballpark Oxygen:
 for:  2 DIVERS  @  1 L/min O2  during:  5885 minutes = ca.   11.00 O2 m**3
 i.e. ca.:    2 tanks @  198 [bar]  with   50 [L] water capacity.
```

52-2 ballparks for required gases (SAT dive)

You could easily overwrite the defaults with your own configuration.

53 The K-values for CNS- & P-OT and the planning routine: „k“

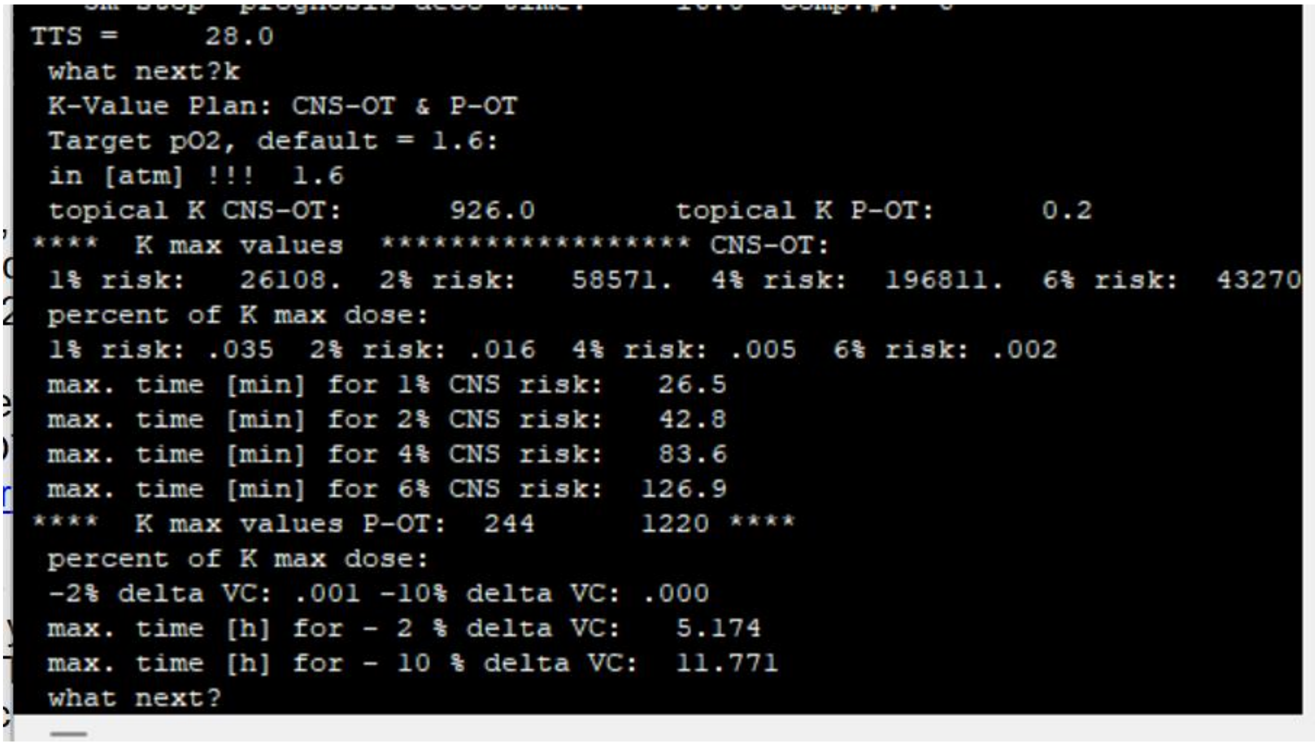
The oxygen toxicity dose for the central nervous system (CNS-OT) you would look up in the NOAA charts, the ox-tox dose for the pulmonary damage you would calculate with the REPEX method: this is what you learned in all your Nitrox/EAN/Trimix/decompression procedures diving-courses.

As already pointed out in the chapters above with oxygen, the big geniuses behind that, Lambertsen, Vann & Hamilton already pointed out that these linear approximations maybe working, but there is no data at hand to prove it!

Since 2005 there is ample evidence for a better method: the „K-value“ indices from Ran Arieli, IDF. (Sources:

- Arieli, R., A. Yalov, and A. Goldenshluger: Modeling pulmonary and CNS O2 toxicity and estimation of parameters for humans. J Appl Physiol 92: 248–256, 2002; 10.1152/ japplphysiol.00434.2001
    - Arieli R. Calculated risk of pulmonary and central nervous system oxygen toxicity: a toxicity index derived from the power equation. Diving and Hyperbaric Medicine. 2019 September 30;49(3):154–160 doi: 10.28920/dhm49.3.154-160. PMID:31523789
    - Aviner B, Arieli R and Yalov A (2020) Power Equation for Predicting the Risk of Central Nervous System Oxygen Toxicity at Rest. Front. Physiol. 11:1007.doi: 10.3389/fphys.2020.01007
    - Arieli, R., Shochat, T., and Adir, Y. (2006). CNS toxicity in closed-circuit oxygen diving: symptoms reported from 2527 dives. Aviat. Space Environ. Med. 77, 526–532
    - Wingelaar TT, van Ooij P-JAM and van Hulst RA (2017) Oxygen Toxicity and Special Operations Forces Diving: Hidden and Dangerous. Front. Psychol. 8:1263. doi: 10.3389/fpsyg.2017.01263
    - An agile implementation of the "K-Value" severity index for cns- and pulmonary oxygen toxicity (CNS-OT & P-OT):
    - https://dx.doi.org/10.13140/RG.2.2.17583.87205

The calculations follow a so-called power function, the recovery function during SI the usual exponential one, but with an expedited behaviour: all the K-values you will find in „z“ & „p“, along with the recovery documented in the PROTOCOL.TXT. The „k“ command projects these calculated values from the topical dive profile into a decompression scenario with a target pO_2 as a free parameter for both CNS-OT & P-OT. The boundary conditions are the pre-set risk-values along a gaussian normal-distribution:



```
TTS =      28.0
 what next?k
 K-Value Plan: CNS-OT & P-OT
 Target pO2, default = 1.6:
 in [atm] !!!  1.6
 topical K CNS-OT:       926.0        topical K P-OT:       0.2
**** K max values ****************** CNS-OT:
 1% risk:   26108.  2% risk:   58571.  4% risk:  196811.  6% risk:  43270
 percent of K max dose:
 1% risk: .035  2% risk: .016  4% risk: .005  6% risk: .002
 max. time [min] for 1% CNS risk:   26.5
 max. time [min] for 2% CNS risk:   42.8
 max. time [min] for 4% CNS risk:   83.6
 max. time [min] for 6% CNS risk:  126.9
**** K max values P-OT:  244      1220 ****
 percent of K max dose:
 -2% delta VC: .001 -10% delta VC: .000
 max. time [h] for - 2 % delta VC:   5.174
 max. time [h] for - 10 % delta VC:  11.771
 what next?
```

52-0-1: K value planning

As per 06/ 2023, there are ideas to replace the UPTD / OTU calculations with another severity index: the ESOT. Details on this one you will find there:

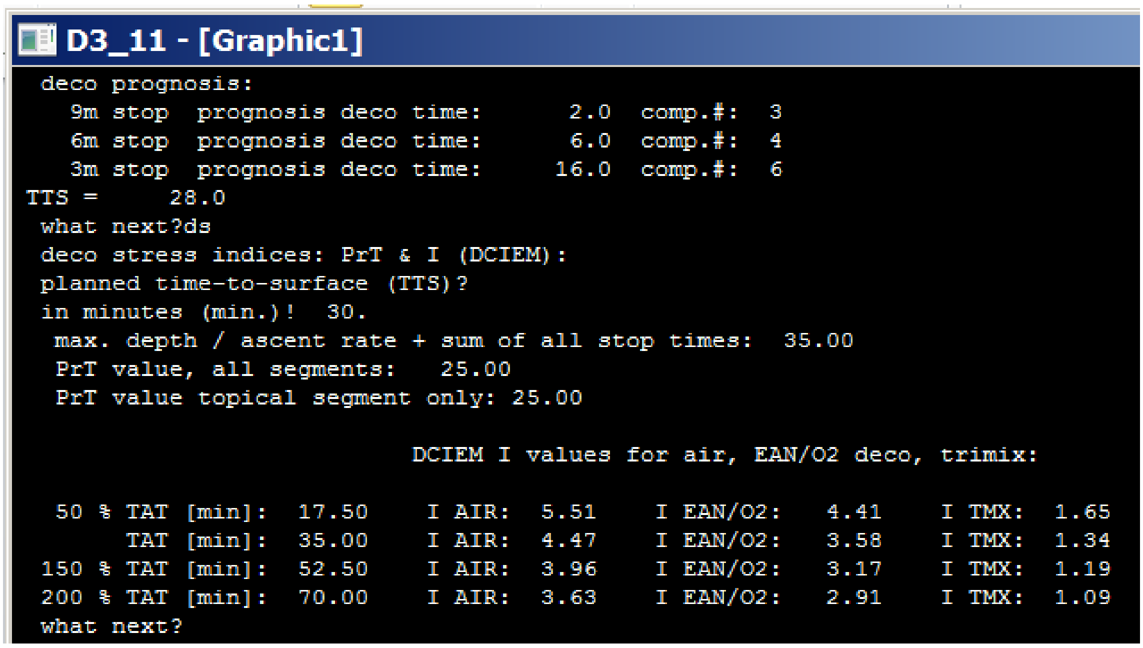
On the calculation of the new oxygen exposure indices (06.06.2023)

i.e. there for a free download:
https://dx.doi.org/10.13140/RG.2.2.14400.92169

Anyway, the ESOT value will be displaced with „p“ and „z“. During normobaric SI, the appropriate recovery-function works.

54 „ds“: the deco stress indices

The PrT values for the topical and all previous dive segments are displayed, along with the DCIEM „I“-index for 3 gas mixes. Since this is heavily dependant on the TTS, it is a free input parameter. As this „I“ does not come in so handy, there is a little table calculated with 50, 100, 150 & 200 % of the keyed-in TTS:



```
 deco prognosis:
   9m stop  prognosis deco time:      2.0  comp.#:  3
   6m stop  prognosis deco time:      6.0  comp.#:  4
   3m stop  prognosis deco time:     16.0  comp.#:  6
TTS =      28.0
 what next?ds
 deco stress indices: PrT & I (DCIEM):
 planned time-to-surface (TTS)?
 in minutes (min.)!  30.
  max. depth / ascent rate + sum of all stop times:  35.00
  PrT value, all segments:   25.00
  PrT value topical segment only: 25.00

                         DCIEM I values for air, EAN/O2 deco, trimix:

  50 % TAT [min]:  17.50    I AIR:  5.51    I EAN/O2:   4.41    I TMX:  1.65
       TAT [min]:  35.00    I AIR:  4.47    I EAN/O2:   3.58    I TMX:  1.34
 150 % TAT [min]:  52.50    I AIR:  3.96    I EAN/O2:   3.17    I TMX:  1.19
 200 % TAT [min]:  70.00    I AIR:  3.63    I EAN/O2:   2.91    I TMX:  1.09
 what next?
```

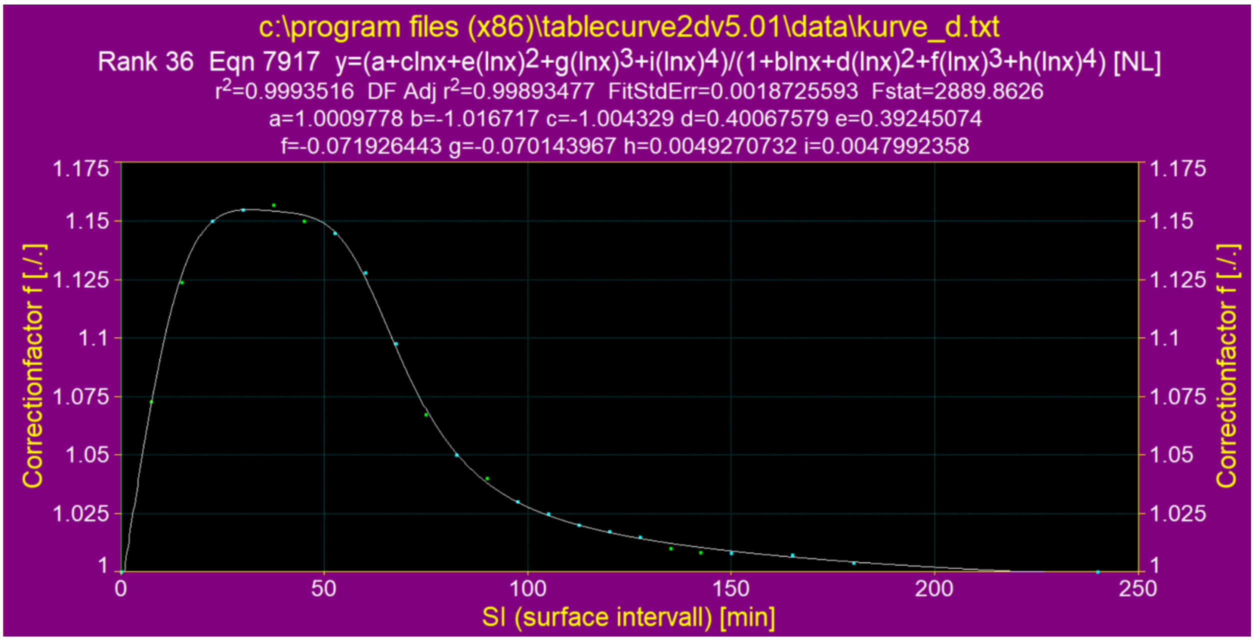
53-1 deco stress indices PrT & DCIEM I

Here, set with „bp“ for 40 m & 25 min, the TTS = 30 min.

There source for the DCIEM „I“ is: DCIEM (2015) deco stress index I,
UHMS 48th. ASM, 2015, Session A4

55 R-/L Shunt

A.A. Bühlmann developped a model for a pulmonary functional R-/L Shunt (Right-to-Left Shunt). With „rl“ you simulate this during SI, i.e.: after ca. 20 min you reach a certain maximum and when the SI reaches 180 min it converges slowly, slowly to 1.0. We fitted the A.A.B. model, curve D, with a non-linear function:



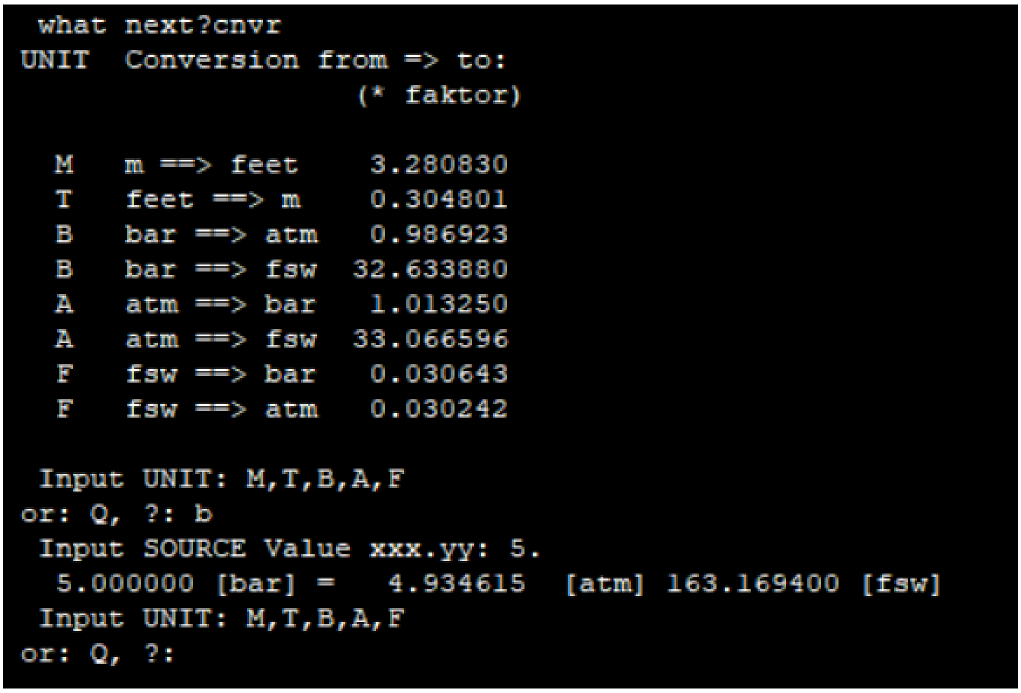
Details & background are covered there:
DOI: 10.13140/RG.2.2.14958.32329

During diving you take the mnemonic: „bsc“ (like „Buehlmann Shunt Correction“). Unlike the real, the original source from AAB, we made it work *also for Helium*.

Details to it & the sources for it there: „Numerical simulation of a pulmonary R-/L shunt“,
DOI: 10.13140/RG.2.2.23856.74245
download for free there:
https://dx.doi.org/10.13140/RG.2.2.23856.74245

56 Conversion of pressure units

With „cnvr“ you invoke a little tool to do this job:



```
 what next?cnvr
UNIT  Conversion from => to:
                    (* faktor)

  M   m ==> feet     3.280830
  T   feet ==> m     0.304801
  B   bar ==> atm    0.986923
  B   bar ==> fsw   32.633880
  A   atm ==> bar    1.013250
  A   atm ==> fsw   33.066596
  F   fsw ==> bar    0.030643
  F   fsw ==> atm    0.030242

 Input UNIT: M,T,B,A,F
or: Q, ?: b
 Input SOURCE Value xxx.yy: 5.
  5.000000 [bar] =   4.934615  [atm] 163.169400 [fsw]
 Input UNIT: M,T,B,A,F
or: Q, ?:
```

56-1: the pressure conversion tool

With „?“ you get the info box, key-in your source unit (exmp.: „b“ for bar), or „q“ for quitting this little tool, and then your source value, here: „5.0“ and you see the converted values in atm and fsw, for eg.

The displayed conversion factors are officially set (USN Rev. 7, Table 2-10)!!!

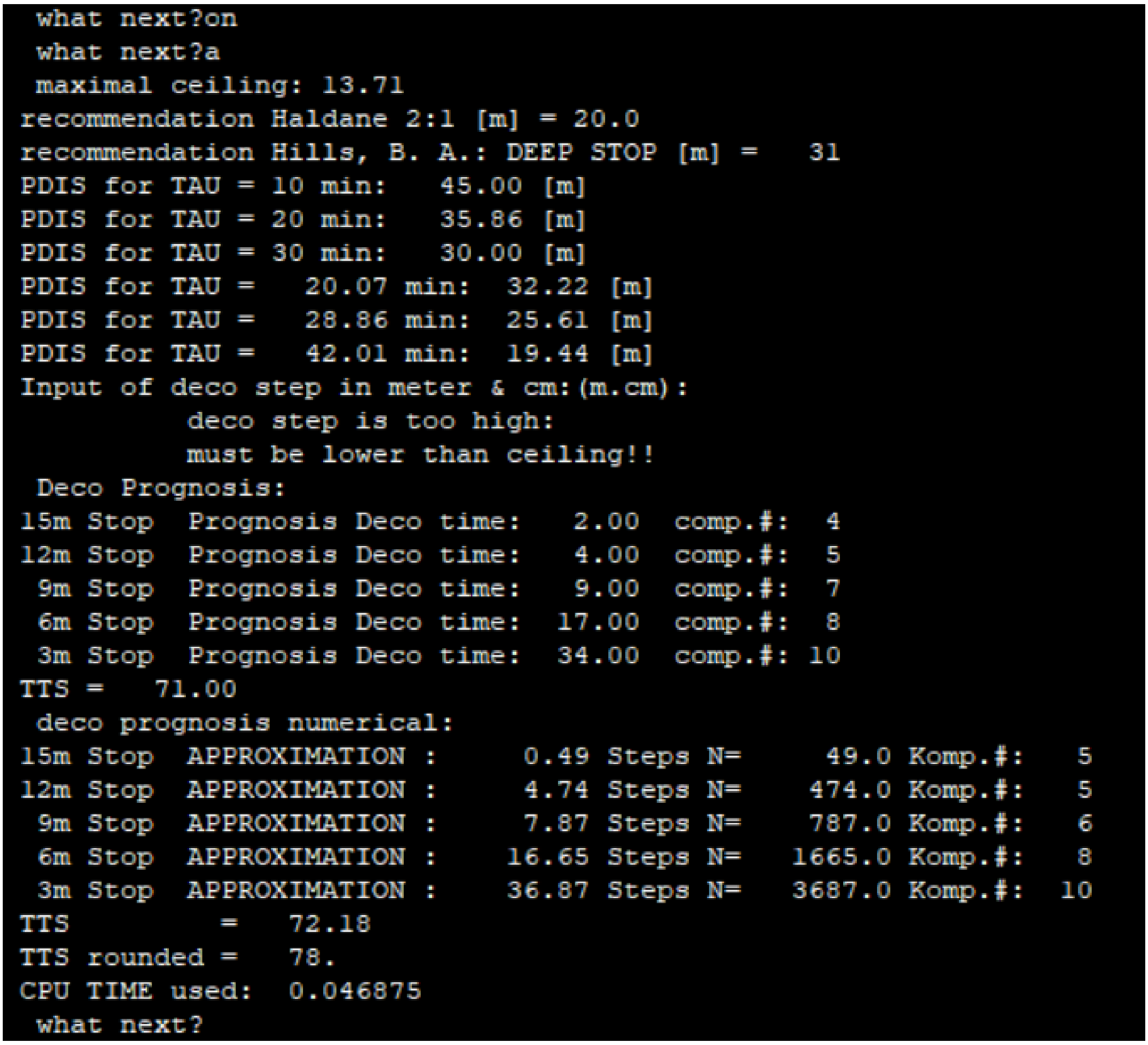
57 The numerical solution of the Trimix Deco-Problem

DIVE could provide you with a complete numerical solution for the desaturation equation for two inertgases (i.e.: trimix). What does that mean? The equation for desaturation for one inertgas is what you see in all the books: it is a so-called „analytical“ solution, i.e.: the deco time is only on ONE side of the equation. You may see this there:

https://www.divetable.info/skripte/theory.pdf equation # 23.

One inertgas is N_2 for air or EANx resp. He for Heliox. If we use 2 inertgases like in Trimix, the analytical solution is no longer possible since the coefficients become time-dependant by themselves, so the times are left AND right of the = sign. This equation has to be solved numerically, the details you will find at the end of the above cited pdf. You tell DIVE to use a numerical procedure via the command „on“.

A TMx dive (50 m, 30 min, Tmx20/40/40) it looks like that:



```
 what next?on
 what next?a
 maximal ceiling: 13.71
recommendation Haldane 2:1 [m] = 20.0
recommendation Hills, B. A.: DEEP STOP [m] =   31
PDIS for TAU = 10 min:   45.00 [m]
PDIS for TAU = 20 min:   35.86 [m]
PDIS for TAU = 30 min:   30.00 [m]
PDIS for TAU =   20.07 min:  32.22 [m]
PDIS for TAU =   28.86 min:  25.61 [m]
PDIS for TAU =   42.01 min:  19.44 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
15m Stop  Prognosis Deco time:   2.00  comp.#:  4
12m Stop  Prognosis Deco time:   4.00  comp.#:  5
 9m Stop  Prognosis Deco time:   9.00  comp.#:  7
 6m Stop  Prognosis Deco time:  17.00  comp.#:  8
 3m Stop  Prognosis Deco time:  34.00  comp.#: 10
TTS =   71.00
 deco prognosis numerical:
15m Stop  APPROXIMATION :     0.49 Steps N=     49.0 Komp.#:   5
12m Stop  APPROXIMATION :     4.74 Steps N=    474.0 Komp.#:   5
 9m Stop  APPROXIMATION :     7.87 Steps N=    787.0 Komp.#:   6
 6m Stop  APPROXIMATION :    16.65 Steps N=   1665.0 Komp.#:   8
 3m Stop  APPROXIMATION :    36.87 Steps N=   3687.0 Komp.#:  10
TTS          =   72.18
TTS rounded =   78.
CPU TIME used:   0.046875
 what next?
```

57-1: numerical solution "ON"

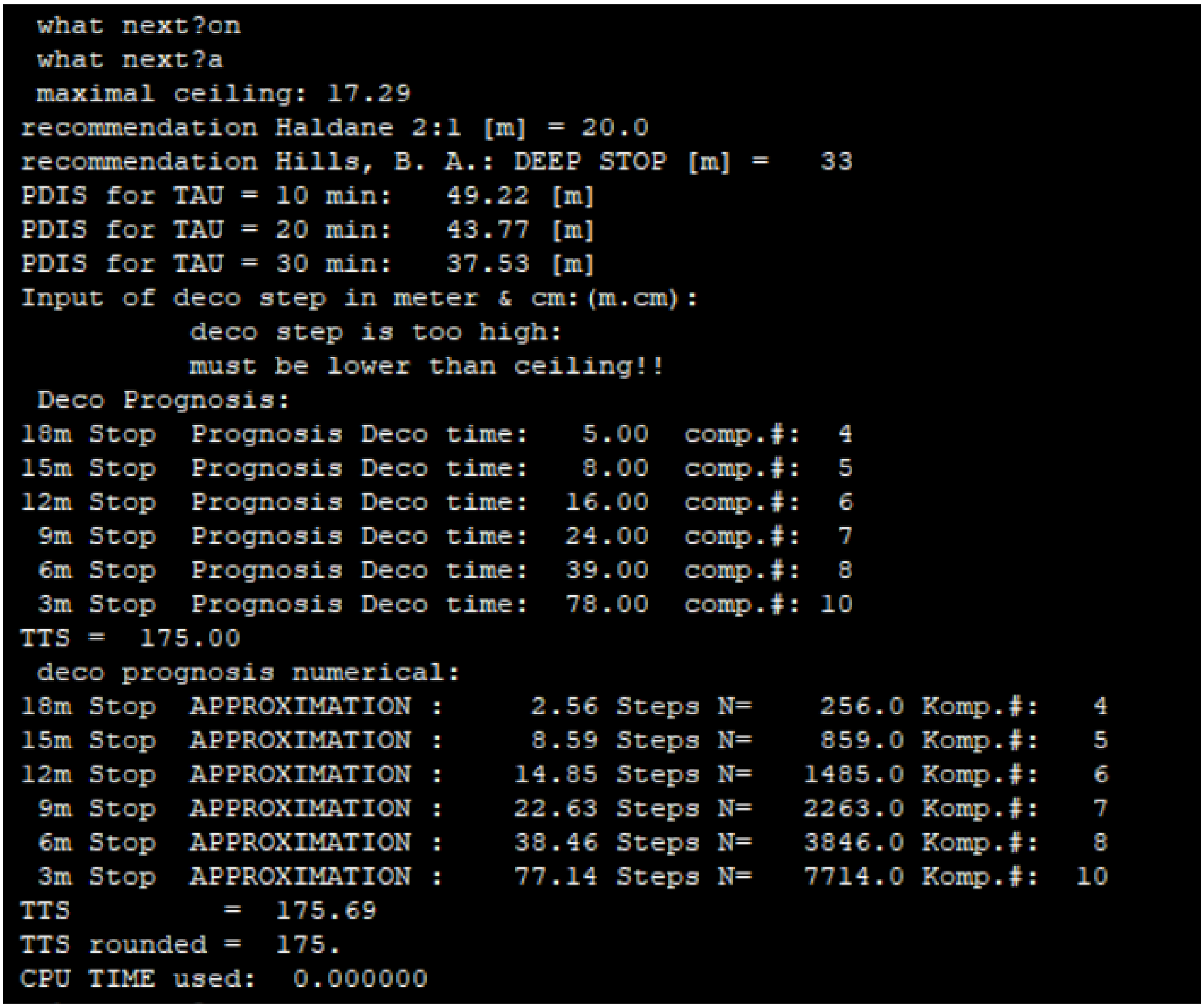
In the above part of the output there is first the standard prognosis via „a“, then follows the output from the numerical solution, indicating the number of steps until convergence (N =) and the total CPU time used in seconds.

If we compare now the difference in the two TTS (78 – 71) it does not look overly dramatic: the real drama comes into play for a great decompression obligation and with a fHe >> ca. 0.4.

The above TTS is calculated in the same manner a lot of deco softwares are doing this: just expanding the standard formula (23) for NDL / deco times to 2 gases and setting the a- & b-coeffcients to a constant per deco step: this is obviously wrong due to the fact that the a- & b-coeffcients themselves are now both time-dependant. But the introduced error is not very big and will probably play no decisive role for trivial TEC dives.

With „**ON**“ you switch this loop on and with „**OFF**“ it is off. That this is something special ony for tri-mixes you could check by yourself: simulate an air / EANx dive with a serious profile and then compare the both TTS: the difference will be nill:

Air, 50 m, 60 min, „on“ and „a“, now check the TTS and, especially the last deco stage:



```
 what next?on
 what next?a
 maximal ceiling: 17.29
recommendation Haldane 2:1 [m] = 20.0
recommendation Hills, B. A.: DEEP STOP [m] =   33
PDIS for TAU = 10 min:   49.22 [m]
PDIS for TAU = 20 min:   43.77 [m]
PDIS for TAU = 30 min:   37.53 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
18m Stop  Prognosis Deco time:   5.00  comp.#:  4
15m Stop  Prognosis Deco time:   8.00  comp.#:  5
12m Stop  Prognosis Deco time:  16.00  comp.#:  6
 9m Stop  Prognosis Deco time:  24.00  comp.#:  7
 6m Stop  Prognosis Deco time:  39.00  comp.#:  8
 3m Stop  Prognosis Deco time:  78.00  comp.#: 10
TTS =  175.00
 deco prognosis numerical:
18m Stop  APPROXIMATION :    2.56 Steps N=    256.0 Komp.#:   4
15m Stop  APPROXIMATION :    8.59 Steps N=    859.0 Komp.#:   5
12m Stop  APPROXIMATION :   14.85 Steps N=   1485.0 Komp.#:   6
 9m Stop  APPROXIMATION :   22.63 Steps N=   2263.0 Komp.#:   7
 6m Stop  APPROXIMATION :   38.46 Steps N=   3846.0 Komp.#:   8
 3m Stop  APPROXIMATION :   77.14 Steps N=   7714.0 Komp.#:  10
TTS         =  175.69
TTS rounded =  175.
CPU TIME used:  0.000000
```

57-2: Comparison of the analytic and the numerical solution for one inertgas

The details and a in-depth analysis of a couple of hundreds mix gas profiles you could find there in the magazine of Underwater Technology:
International Journal of the Society for Underwater Technology, November 2012:
Variations in the TTS: where do they come from?
SUT140-31-55224.pdf

(resp. there: Tech Diving Mag, Issue 05 / 2011:
Decompression calculations for trimix dives with PC software;
gradient factors: do they repair defective algorithms or do they repair defective implementations?

And a funny glance at a couple of software products with serious errors (which DIVE is as well not immune against …) you could find there;

Tech Diving Mag, Issue 07 / 2012:
[Mother Nature is a Bitch: beyond a pO2 of 1.6]

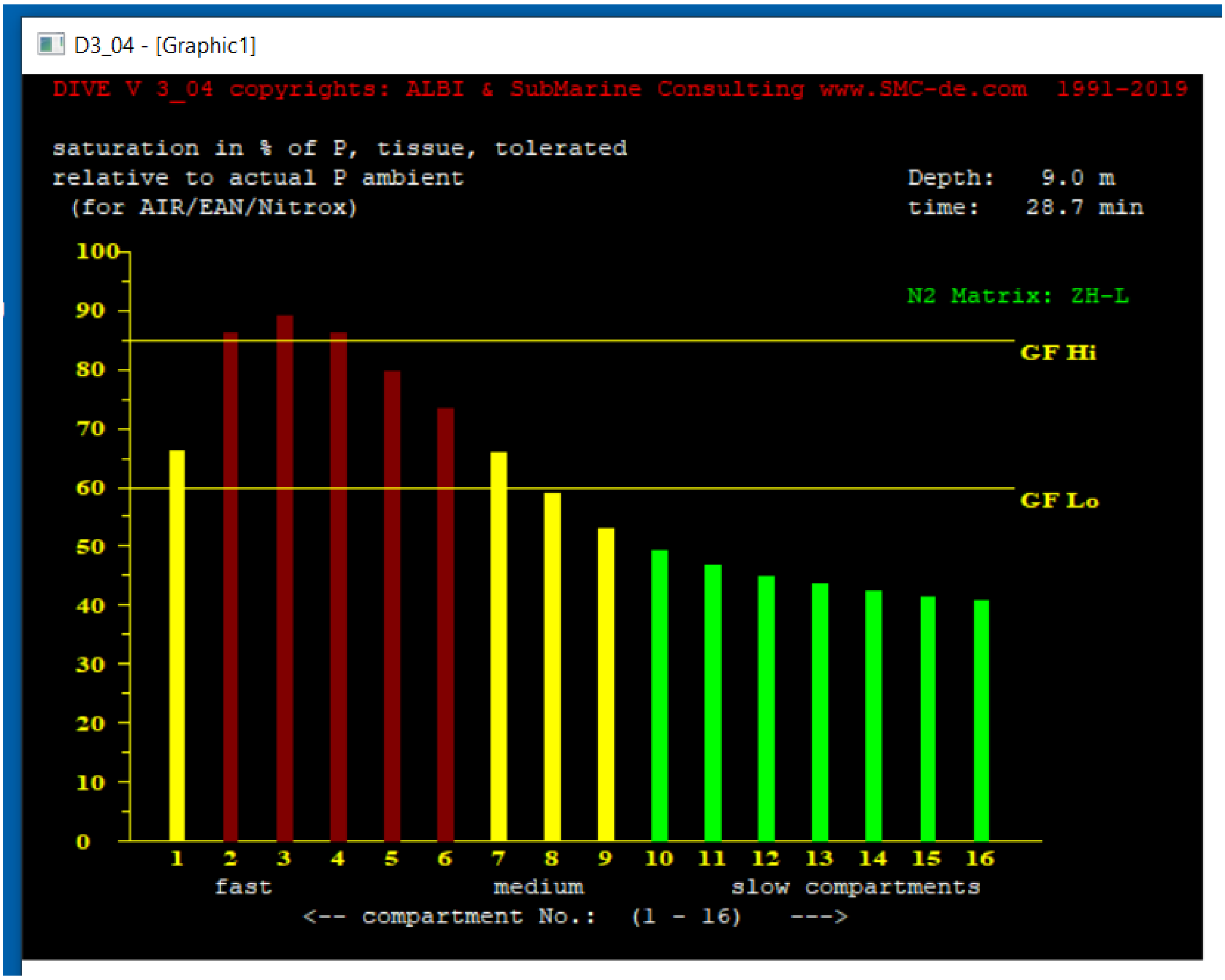
58 „%P“ = the percent plot

With „%p“ you will see the calculated compartment saturations but not as an absolute value in Bar, instead as a percentage of the allowed / tolerated value. The color scheme (green, yellow, red) is according to the idea from the DAN DRA (**D**ecompression **R**isk **A**nalysis):

0 <= x <= 0.49:	**green**
0.5 <= x <= 0.69:	**yellow**
0.7 <= x <= 1.0:	**red**

Table 6: DAN DRA parameters

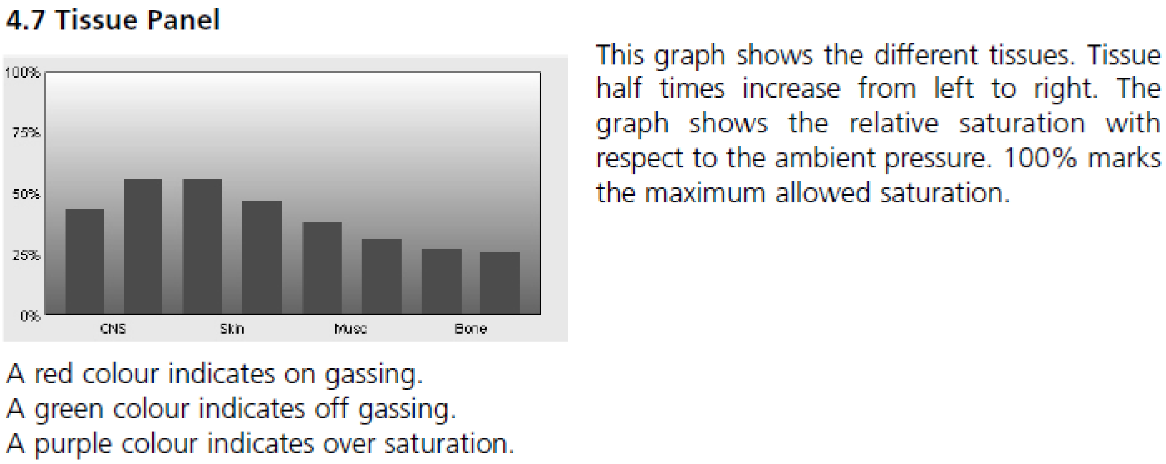
For our test dive: 42 m, 25 min, „a“ to the first stop at 9 m and the GFs set to 0.85 / 0.6:



```
DIVE V 3_04 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2019

saturation in % of P, tissue, tolerated
relative to actual P ambient                               Depth:   9.0 m
 (for AIR/EAN/Nitrox)                                      time:   28.7 min
```

58-1: %P: the "percent plot" with GF set and the DAN DRA colors

These bar charts you could now compare with the usual other products which come with a dive computer:



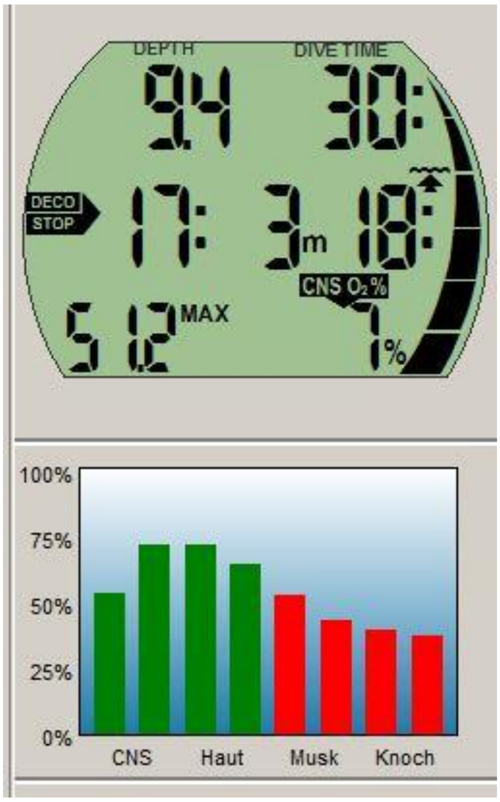
4.7 Tissue Panel

This graph shows the different tissues. Tissue half times increase from left to right. The graph shows the relative saturation with respect to the ambient pressure. 100% marks the maximum allowed saturation.

A red colour indicates on gassing.
A green colour indicates off gassing.
A purple colour indicates over saturation.

58-2: Inert gas saturation according to UWATEC, source: SmartTRAK manual ENG (p.19)

Resp. after a 50 m dive at a 9 m stop:



58-3: Inert gas saturations, source: my SmartTRAK log book

It reads on the x-axis: CNS, skin, muscles, bones

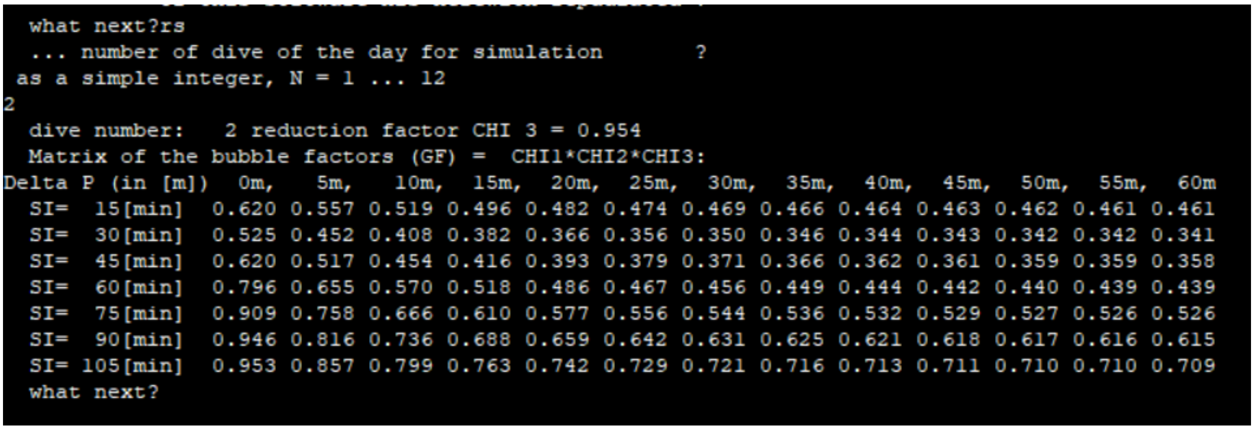
How could you have access to the DAN DRA? Very easy: save your dive profiles in the DAN DL7 level 3 Fileformat (*.zxl) and put them there:

https://www.diversafetyguardian.org/

59 „RS“ = the RGBM Simulator

This simulator calculates the so-called „bubble factors“ and outputs them as a little matrix. These „bubble factors“ in turn are simply the product of the 3 „reduction factors“ (RF) of a RGBM model; their names being: CHI 1, CHI 2 and CHI 3. These factors are reducing the used M-values via:
CHI 1: the length of the SI
CHI 2: „deeper than previous“ or „reversed profile“
CHI 3: multi-day diving frequency (no. of dives within 24 h).

The source for this algorithm is:
ON MODERN DIVE COMPUTERS AND OPERATION, Protocols, Models, Tests, Data, Risk And Applications; by B.R. Wienke and T.R. O’Leary (NAUI TEC paper, on p. 32 of this PDF).



```
  what next?rs
  ... number of dive of the day for simulation       ?
 as a simple integer, N = 1 ... 12
2
  dive number:   2 reduction factor CHI 3 = 0.954
  Matrix of the bubble factors (GF) =  CHI1*CHI2*CHI3:
Delta P (in [m])  0m,   5m,   10m,  15m,  20m,  25m,  30m,  35m,  40m,  45m,  50m,  55m,  60m
  SI=  15[min]  0.620 0.557 0.519 0.496 0.482 0.474 0.469 0.466 0.464 0.463 0.462 0.461 0.461
  SI=  30[min]  0.525 0.452 0.408 0.382 0.366 0.356 0.350 0.346 0.344 0.343 0.342 0.342 0.341
  SI=  45[min]  0.620 0.517 0.454 0.416 0.393 0.379 0.371 0.366 0.362 0.361 0.359 0.359 0.358
  SI=  60[min]  0.796 0.655 0.570 0.518 0.486 0.467 0.456 0.449 0.444 0.442 0.440 0.439 0.439
  SI=  75[min]  0.909 0.758 0.666 0.610 0.577 0.556 0.544 0.536 0.532 0.529 0.527 0.526 0.526
  SI=  90[min]  0.946 0.816 0.736 0.688 0.659 0.642 0.631 0.625 0.621 0.618 0.617 0.616 0.615
  SI= 105[min]  0.953 0.857 0.799 0.763 0.742 0.729 0.721 0.716 0.713 0.711 0.710 0.710 0.709
  what next?
```

59-1: Matrix of the RGBM "bubble factors"

First you have to input the number of your repetitive-dive you want to simulate: if it is „1“ it is just the first dive of the day; as a matter of fact you could impinge on your 1st dive as well the RGBM gradient factors: no problem with it. If you put „2“, it is the 2nd dive of the day, a rather traditional repetitive dive. Your rep-dive could lead into the same depth (Delta P in [m] = 0, on the very left side, the 3rd. column), otherwise you search an estimate in m. It runs until 60 m: this would be, say if your first dive would have been to 20 m, imply a bottom depth of 80 m. Then you look for the appropriate SI in min (2nd column) between these 2 dives: the SI runs from 15 (1st. line) to 105 min (last line). Around 100 min the CHI 1 converges very rapidly to 1.0 The output is the matrix of the bubble factors, these are considered as gradient factors (GF) with the following: GF = CHI1*CH2*CHI3. You use them as a standard GF for further simulation with the „gf“ command. This is how the most products work which pretend to have a „full blown“ model, but instead work with a so-called „RGBM folded over ZH-L“. To put now the whole procedure together: with the

→ No. of your repetitive dive
→ the length of your surface intervall SI in min, and
→ Delta P, the difference of the bottom-depths in m
You read off the **fitting GF** from this matrix, you take that and:
→ simulate this particular repetitive dive again.

Here you have now the freedom of using this GF at your discretion: only as a GF Low, then the GF High remains at 1.0, or you set both, i.e. GF Hi & GF LO to the new RGBM value.But don’t overdoe it with the GFs: around ca. < 0.4 they loose slowly their physiologic meaning (if there was any …)

60 Precision of DIVE:

The basic equation for calculation of the hydrostatic pressure p looks like that:

$$p = \rho * g * h$$

with:

ρ , specific density

g , acceleration constant

h , geometrical length of the water column

DIVE uses the accepted standard values. But if you use the usual (diver-)ballparks like:

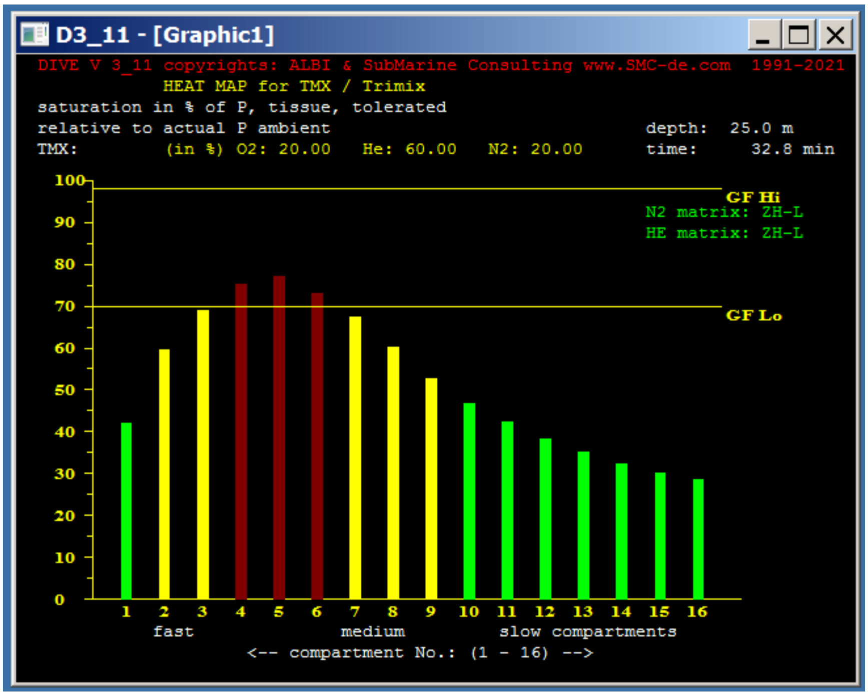
$\rho = 1,000\ kg/m^3$, $g = 10.0\ m/sec^2$ (and $p_0 = 1,000$ mbar) you will get for a 10 m water column exactly the pressure of 10^5 Pascal, i.e. 1.0 Bar. Now with the SAC of 20 L/min you will get in 20 m depth after 10 min really 20 * 3 * 10 = 600 L … The deviations against reality are marginal and for trivial TEC/rec dives not really relevant; but quite to the contrary for the other dive operations …

You can reach the „diver's ballparks" easily by a factor from the default values of: 10,000 / water density * acceleration constant = 1.021545; i.e.: ca. 1022.0 in „DI" as an input!

To not overdo it with precision, we friendly neglect the decrease of the acceleration constant from the pole to the equator of round-about 0.5 %:

that is: $g_{0,\ pole}$ = ca. 9.832 m/s² → $g_{0,\ equator}$ = ca. 9.780 m/s².

61 „HM" = Heat Map



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2021
                 HEAT MAP for TMX / Trimix
saturation in % of P, tissue, tolerated
relative to actual P ambient                             depth:  25.0 m
TMX:          (in %) O2: 20.00   He: 60.00   N2: 20.00      time:     32.8 min
                                                         N2 matrix: ZH-L
                                                         HE matrix: ZH-L
```

61-1 Heat map for TMX

„HM“ creates a heat map, i.e.: simplified traffic-light chart for trimixes, very much like the „%p“ does for Air/EAN. The color coding scheme is the same, acc. to DAN DSG. So for f_{He} = 0.0, „%p“ and „hm“ should produce absolutely identical outputs …

62 „CLR“ = „CLEAR“, table with the „default“- values

```
      SPRACHE = 'EN'
C
  800 NZWO = 0.79
      OZWEI = 0.21
      HELIUM = 0.0
      AMV = 25.0
      RQ = 1.0
      OXCONS = 0.25
      PSTART = 1.013
      BKORR = 'N'
      LATENCY = 'N'
      FIRSTOP = 3.0
      LASTSTOP = 3.0
      GFFLAG = 'N'
      GFHI = 1.0
      GFLO = 1.0
      AR = 9.0
      O2HWZ = 90.
      NUMFLAG = 'OFF'
      DICHTE = 998.203
      G0 = 9.80665
      TEMPRT = 20.0
```

```
      K_INDEX = 0.0
      K_AKTUEL = 0.0
      POT_IND = 0.0
      POT_AKT = 0.0
       ESOT_IND = 0.0
       ESOT_AKT = 0.0
      PRT = 0.0



      DO 801 I = 1, 16
      TAU(I)      = N2TAUORG(I)
      LAMBDA(I)   = N2LAMORG(I)
      HETAU(I)    = HETAUORG(I)
      HELAMBDA(I) = HELAMORG(I)
  801 CONTINUE
C
C         INITIALISIERUNG
C
      DO 200 I = 1, 16
      GFHIA(I) = 1.0
      GFLOA(I) = 1.0
      HEGFHIA(I) = 1.0
      HEGFLOA(I) = 1.0
      PGEWEBE(I) = NZWO * PSTART
      HEPGEW(I) = HELIUM * PSTART
      PGEWSUM(I) = PGEWEBE(I) + HEPGEW(I)
      PUTOL(I) = 0.58
      CEILING(I) = 0.0
  200 CONTINUE
C
```

Table 7: default values

With a „CLR“ all the variables of **the dive** will be set from run-time to default. This is similar to ending DIVE and starting it again, except that the matrices stay as you have put them.

63 Overview of the ASCII interface of DIVE

Here is smal list with the overview of all commands which serve the ASCII interface:

„Z“ shows all parameters connected with the dive profile and the compartments. You can save / store these data for later use in an ASCII / TXT file, pls. cf. next command below and attachment B

„F“ asks for a filename <filename> of exactly the above cited file, afterwards you have to decide if you want to write („W“) or read („R“). The place looks like that: C:\DIVE\PROT\<filename>.TXT

„NC“ resp.:
„HC“ the coefficients matrices:
C:\DIVE\PROT\N2COEFF.TXT
C:\DIVE\PROT\HECOEFF.TXT

the protocol file (the “run time”):

C:\DIVE\PROT\PROTOCOL.TXT

64 Planning Alternatives

As per above, this topic as well is not directly related to our focus here. But a couple of remarks and DIVE could be helpful to do this job.

Normally you plan longer / deeper diving missions in 2 further variants to be covered against Murphy’s laws. You will then print the results, laminating it or putting it on wet-notes. My procedure was to write it with a thick black waterproof felt pen on waterproof adhesive tape and putting that on the forearms of my dry-suit.

These 2 variants are usually an:

- abort plan
- contingency plan

The used parameters are looking usually like that:

- abort plan: less bottom depth, less bottom time
- contingency plan: more bottom depth, more bottom time

A wise move would be to plan everything with your back-gas only, i.e.: no deco mixes. Thus the maximal super-catastrophy of loosing all stage tanks is covered. Key in a meaningful stress factor, say 1.5 or so. A relatively precise knowledge of you SAC with / without workload is indispensable. Little example? Here we go with DIVE:

desired profile: 39 m / 20 min on air
abort Plan: 20 or 30 m / 10 to 15 min
contingency plan: 42 m / 25 to 30 min

How could DIVE help you efficiently? You start with the abort plan and add extra times, depths incrementally:

“d” → 30.00, 15.
“a” → noting abort plan, then “clr”
“d” → 39.00, 20.
“a” → noting desired profile, then: “clr”
“v” → adapt your SAC
“d” → 42.00, 30.
“a” → noting contingency plan;

Now you follow this with subsequent “d” commands, during deco phases you may adapt your SAC with „v“ and your ascent rate with „ar“. Thus the run-time is automatically generated with the amounts of gas you need. And because your gas is suffcient for the contingency plan it is as well automatically suffcient for the other variants beeing shallower & shorter.

As the last step you do now your desired profile the same way, just use „m“ to adapt for your deco gases you may now use and check the %CNS and / or OTUs in the protocol file.

65 A simple hint for Novice-Experts and -TEC-Divers:

„Do not fall prey to the computer narcosis!“ (Hills, B.A.)

„You may optimize your deco on the PC or a dive computer: but not your body in the water!“ (© ALBI)

I.e.: with the many possibilities DIVE offers, you could get the idea, that a sound training (= a good instructor), a little bit of experience (= many succesfull dives), common sense and a proper planning with a reasonable dive-buddy drives the many „options & features“ of fragile high-tech dive computers and overly expensive desktop-deco software into fecklessness!

Next important hint:
Do not believe blindly the display of your dive computer (or your deco-software): ALL of these products may have bugs, even DIVE 😊! And „may have“ means clearly: there are bugs! It is just a matter of time, that they arise!

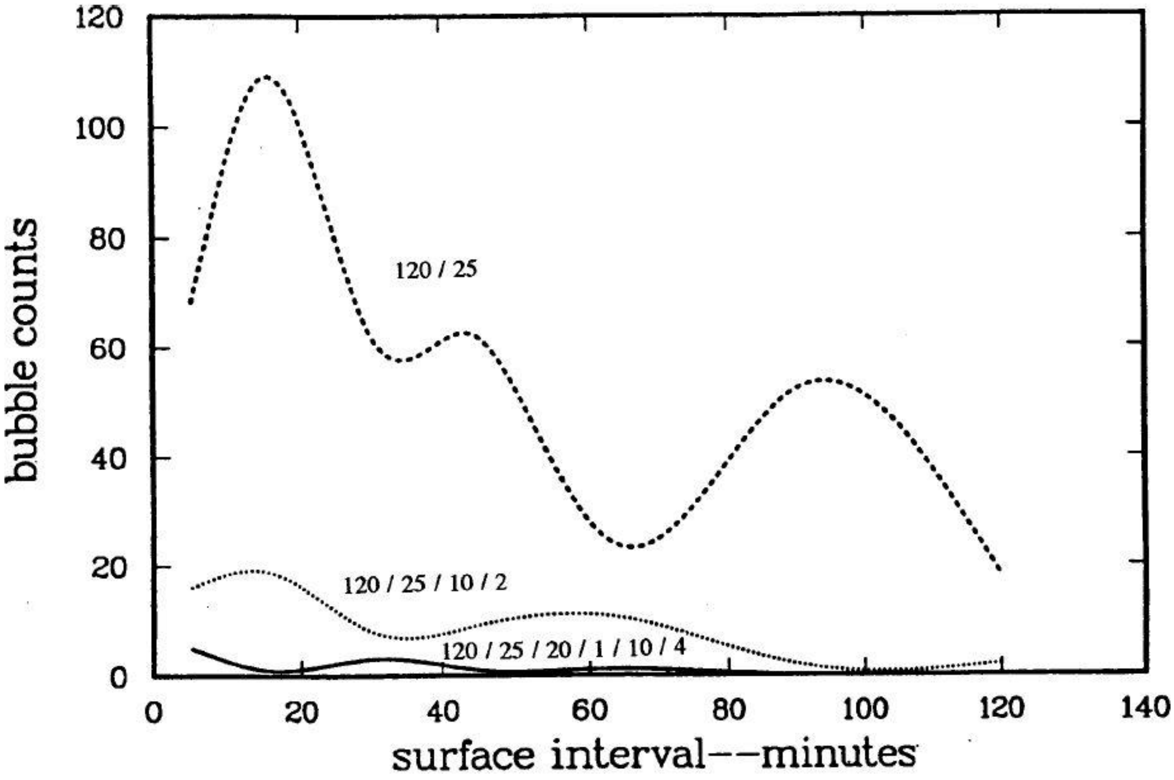
So if you dive well outside the rec-enveloppe (say > 30 m, > 30 min, mix gas) then try to confirm or compare your dive plans or run-times with validated mix gas tables from the U.S. Navy, DCIEM, COMEX etc. If you have: run ultra-sound doppler-readings after your dives and then modify your run-times with personal safety factors.

And my final one:
„It doesn’t matter which dive computer or which deco-model you use: provided, there is a sound implementation“ (© ALBI)

66 A Way Out of the „NDL“ dilemma?

As per above, once more: this topic as well is not directly related to our focus here of using the software. But a couple of remarks and DIVE could be helpful to do this job; first there is an information concerning ultra-sound dopplerscores after a „NDL“ dive:

REDUCTION IN DOPPLER BUBBLE COUNTS FOLLOWING SAFETY STOPS



Safety stops have considerable impact on Doppler sounded VGE measurements, according to Pilmanis. Following a dive to 30 m (100 fsw) for 25 minutes, the top curve registers VGE counts over increasing surface time. The lower two curves depict the count after a brief stop for 2 minutes at 3 m (10 fsw), and then 1 minute at 6 m (20 fsw) followed by 4 minutes at 3 m (10 fsw). Reductions by factors of 4-6 are apparent. Whether VGE correlate with susceptibility to DCS or not, bubble reduction in the pulmonary circulation is impressive with shallow safety stops.

66-1: Doppler Scores after NDL dives

The sources are:
Andrew Pilmanis, ONR; and: Pilmanis AA. Intravenous gas emboli in man after compressed air ocean diving. Contract Report, N00014-67-A-0269-0026. Washington, D.C.: Office of Naval Research, 1976; Proc. of Dive Computer workshop, AAUS, 1988, p. 177 resp. [8], p. 40.

These tests have been done during the ‘76s, but instead of the labels with 120 feet the dives have been only to 100, pls. cf. the image caption. On the y-axis you see the doppler scores of the 3 profiles and the x-axis is the SI in min. You would reduce bubbling if you do a safety stop (10 feet, 2 min). But this reduction is more dramatic, if you do „2 of a kind“: that is a 2nd stop one storey down (20 feet, 1min; 10 feet, 4 min).

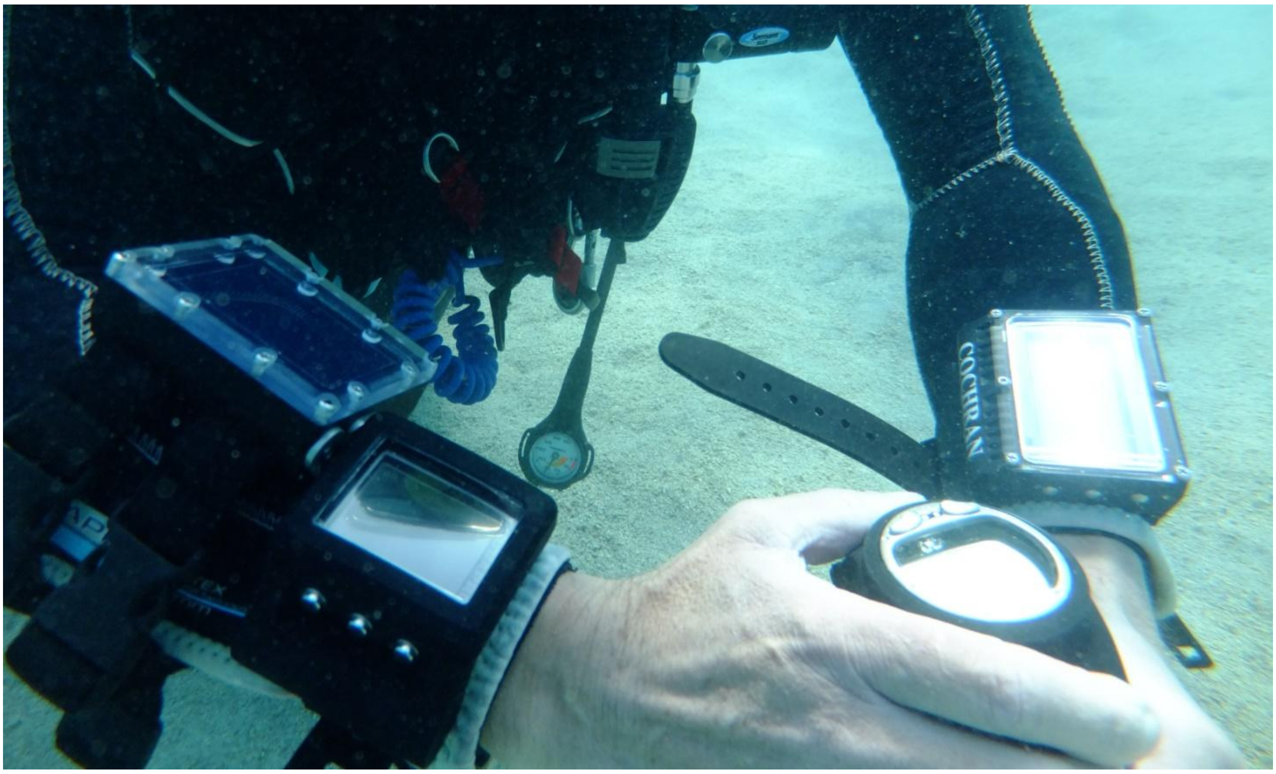
If you now take into account that a real efficient stop is minimum 2 minutes due to the finite round-trip time of blood through your body, you could do better for your „NDL“ dives with:

9 m, 2 min; 6 m, 4 min; 3 m, 4 to 6 min at discretion.

That is: you increased your TTS by ca. 10 min: DIVE would assist you in calculating the extra gas you need for it.

If you want to back-up your plan with any approved diving table: take this 10 min and subtract this from your planned bottom time from the table. E.g: 30 m, 20 min is any table entry, then you dive max.: 20 - 10 = 10 min at the bottom.

If you prefer „CAD“ (Computer Assisted Diving) with the built-in flexibility of deviating from your printed and meticulously concocted run-times: make sure you have reasonable fall-back options, but don’t overdo it:



66-2: fall-back with 4 dive computers

67 Literature and further reading

- My manual for the PADI „DIVE COMPUTER & DIVE TABLES“ Specialty (german)
  - https://www.divetable.info/skripte/tables.pdf
- Decompression: manual for our **„deco workshop“ here in Esslingen/Germany.** In the meantime this 800 pages volume is a sort of reference for TEC divers in the D-A-CH region. If you have a good working command of the german language, then you may enjoy the short sample and the TOC:
-
  - https://www.researchgate.net/publication/369196910_Leseprobe_Dekompression
- Theory of decompression calculation:
  - https://www.divetable.info/skripte/theory.pdf

- more **diving literature** general:
    - https://www.divetable.eu/BOOKS/index_e.htm
- and also the **D³ archive** with many more resources …:
    - https://www.divetable.eu/D3/index.htm

68 Motivation, history and histories and some back-ground info

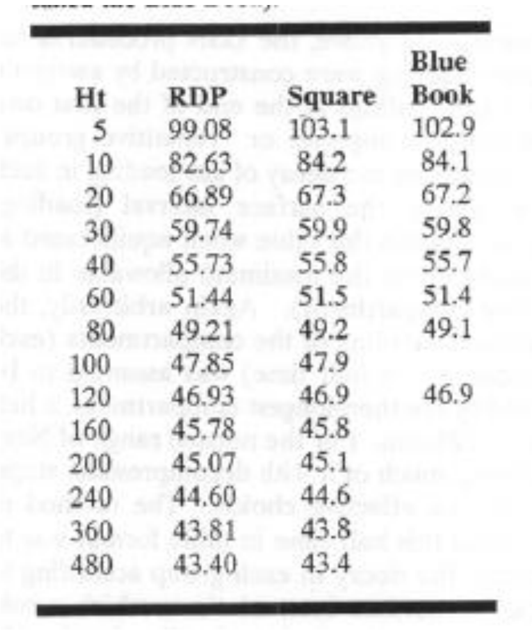
(the idea, why i made „DIVE“)

This little program „DIVE“ is a software to simulate dives, that is exposure to overpressure during breathing. It can simulate various physiologic situations specific to recreational (rec), technical (TEC) bounce dives, to saturation (sat) dives, caisson- or tunnel work and, as well apnea (breath hold dives, if you make sensible adaptions to a lot of parameters). The whole bundle, incl. manual is for free: it is the shareware version of s.th. we use commercially.

One of the objectives was / still is to show the advanced diver how a dive computer works internally and why a decompression / dive table looks the way it looks.

This stems from the beginning of my career as a PADI instructor in the ‘80s of the last year-thousand and that during my IDC a couple of course directors asked me to create s.th. like that. So i got in touch with Jeff Nadler, the then president of DSAT©. As probably one of the first guys in good old europe i got a copy of the famous DSAT script **[3]** to make use of the RDP coefficients. Which, in the end, we never did, because, as times went by, the focus shifted slowly, slowly to „real deco dives“ … 😊.

(To be completely honest with my sources, the ΔM, needed for deco times, are missing …



Ht	RDP	Square	Blue Book
5	99.08	103.1	102.9
10	82.63	84.2	84.1
20	66.89	67.3	67.2
30	59.74	59.9	59.8
40	55.73	55.8	55.7
60	51.44	51.5	51.4
80	49.21	49.2	49.1
100	47.85	47.9	
120	46.93	46.9	46.9
160	45.78	45.8	
200	45.07	45.1	
240	44.60	44.6	
360	43.81	43.8	
480	43.40	43.4	

68-1: RDP HT vs. M0

Source: [3], p. 21

So our manual here focuses on the pure handling of the software, nevertheless there are lot of references and hints to further reading. The physiologic backgrounds and more sources, however, are compiled in our omnibus volume of ca. 800 pages of the „deco manual“ (german, sample is there:
https://www.researchgate.net/publication/369196910_Leseprobe_Dekompression
…).

Another focus of DIVE though, surfaced only during the last 10 years: that TEC divers wanted to control their dearly bought mix gas computers or deco softwares.

The archetyp of the DIVE software from 1991 until 2014 was written in FORTRAN 77 for an MS FTN compiler (Version 5). During 2014 → 2023 we have used several new platforms. As per today: MS Visual Studio 2022 with a modern Intel-Compiler FTN IFX:

```
Compiling with Intel® Fortran Compiler 2024.0.2 [Intel(R) 64]
```

The source codes of the little DIVE programs are approx. ca. 15,000 lines of code, ca. 400 kB. The executables (*.exe) use with all required DLLs (dynamic link libraries) ca. 2.5 MB. They can be run on any Windows®-OS with 64 Bit from Win7 on.

The internal calculations are done basically with 2 * 64 = 128 Bit, i.e. the precision runs to approx. 30 decimal places, so the calculated times and saturations are relatively exact (But that does not mean, that the deco-models are exact!!!! (*)) A couple of dive tables have been calcluated during the ‘80s and thus with an 8 bit technology. This goes **only** with DOUBLE PRECISION maximal to the 3rd. decimal place. So for very long and / or very shallow dives there are discrepancies in the sub-5-min area.

In contrast to the other, usual available products, DIVE offers a couple of unique simulations like PMRC, R/L shunt, various deep stop recommendations, PDIS, VGM and a temperature adaption, corresponding approximately the „ADT“ (=adaptive) of the ZH-L 8 breed, oxygen corrections, RGBM, … pls. cf. the appropriate chapters.

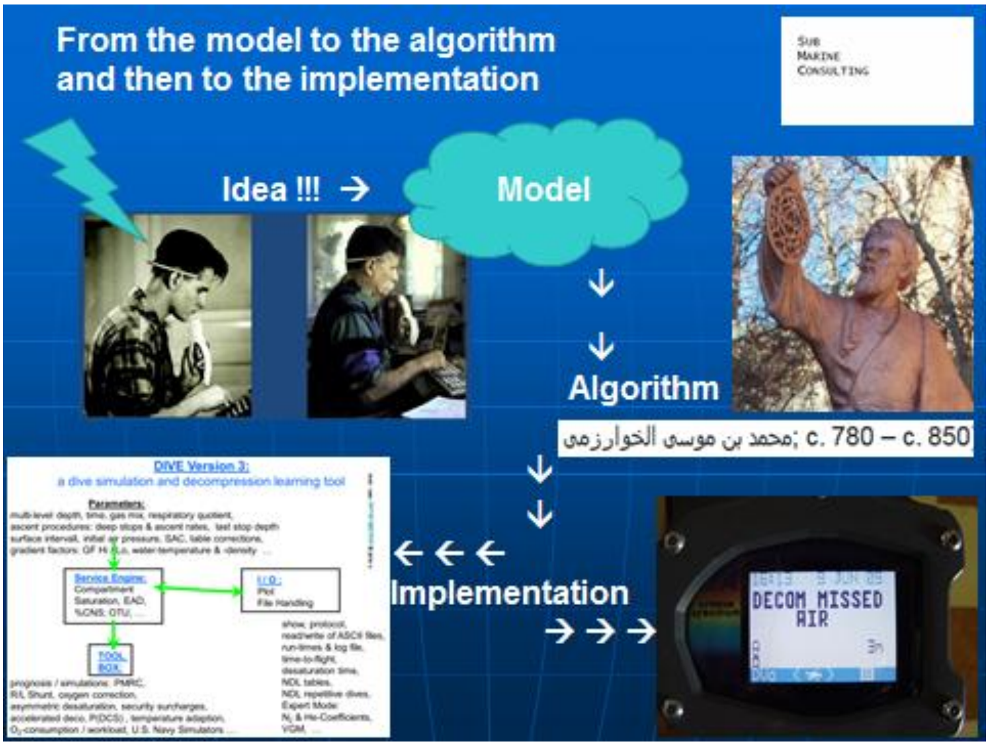
As well you could simulate with only a couple of easy inputs relatively complex operating scenes like:

→ ICD (isobaric counter-diffusion)
→ O_2 prebreathing
→ diluent hypoxy
→ change in (skin-) perfusion with increased
→ workload under water, or
→ cooling or, as well
→ journey to a mountain lake.

As well we have abdicated from any graphical knick-knack: the cemetry of numbers should make clear the wealth of internal operations before any truncated number appears without comment on a dive computer display.

Rounding according to the paradigm „next bigger/smaller integer for depth / time“ will appear only in the prognosis outputs in order to compare with other published stuff.

(*) To put this one as well into perspective have a look at the following chart:



From the model to the algorithm and then to the algorithm and then to the implementation

DIVE Version 3:
a dive simulation and decompression learning tool

Parameters:
multi-level depth, time, gas mix, respiratory quotient,
ascent procedures: deep stops & ascent rates, last stop depth
surface interval, initial air pressure, SAC, table corrections,
gradient factors: GF Hi /Lo, water-temperature & -density ...

Service Engine:
Compartment Saturation, EAD, %CNS, OTU, ...

I / O :
Plot
File Handling

TOOL BOX:

prognosis / simulations: PMRC,
R/L Shunt, oxygen correction,
asymmetric desaturation, security surcharges,
accelerated deco, P(DCS) , temperature adaption,
O_2-consumption / workload, U.S. Navy Simulators ...

show, protocol,
read/write of ASCII files,
run-times & log file,
time-to-flight,
desaturation time,
NDL tables,
NDL repetitive dives,
Expert Mode:
N_2 & He-Coefficients,
VGM, ...

68-2: Idea / Model / Algorithm / Implementation

The above concatenated steps are indeed really separate and on each step there could be made errors. Concerning the implementation, being it in a piece of plastic (printed table) or a piece of silicon (dive computer) we recommend the following procedures:

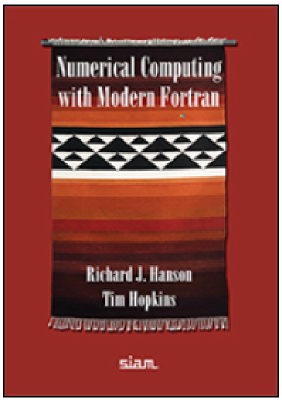
→ documentation of the used variables
→ code review
→ quality control

This should be done transparently, very much like the crash-test results from automobiles, the software constructs being standardized and public; serious dive computers should have an SIL level according to IEC 61508 (safety integrity level). (By the way, the guy on the left hand-side still having a banana after 40 years of reasoning is Bill Hamilton, the other one on the right hand side is the persian scientist Muhammad Ibn Musa Al Chowarismi (arab.: محمد بن موسى لخوارزمي), donating the geographical part of his family name (yellow) to our modern word „algorithm“). Oh yes, and, as well this one: a word from the title of one of his famous books: „ …. Al Jabr …“ (لكتاب المختصر في حساب الجبر و المقابلة) made it as well into our language through a sound shift to „algebra“.

Utilities for the software technology:

Numerical Methods and Source-Code from:
Society for Industrial and Applied Mathematics (http://www.siam.org/)

- resp. from this source:



Numerical Computing with Modern Fortran

Richard J. Hanson and Tim Hopkins

68-3: Numerical Computing with Modern FORTRAN

And, these as well:

- The Fortran 2003 Handbook The Complete Syntax, Features and Procedures
Jeanne C. Adams, Walter S. Brainerd, Richard A. Hendrickson, Richard E. Maine, Jeanne T. Martin; ISBN 978-1-4471-5942-1 Springer

- Modern Fortran Explained
Michael Metcalf, John Reid, Malcolm Cohen; ISBN 978-0-19-960142-4 Oxford University Press

Performance- or other problems could be solved via the toolbox from Microsoft (free of charge):
- Sysinternals Seite: http://live.sysinternals.com/

Info concerning the DLLs (Dynamic Link Libraries), as well free of charge:
- Dependency Walker Tool (http://www.dependencywalker.com/)

69 Alphabetical Index

70 Appendix A: Quality Assurance for DIVE V 3_xx; from: 2021

Comparison of the DIVE output with a couple of standard tools & tables:

If after updates, bug fixes or patches serious bugs are revealed, we have the chance with the following data to investigate into the errors of programming/writing/reasoning/computing …
As per above, the sources have their reference no. [ ] from:
http://www.divetable.eu/BOOKS/index_e.htm The QA is done along the following 11 scenarios:

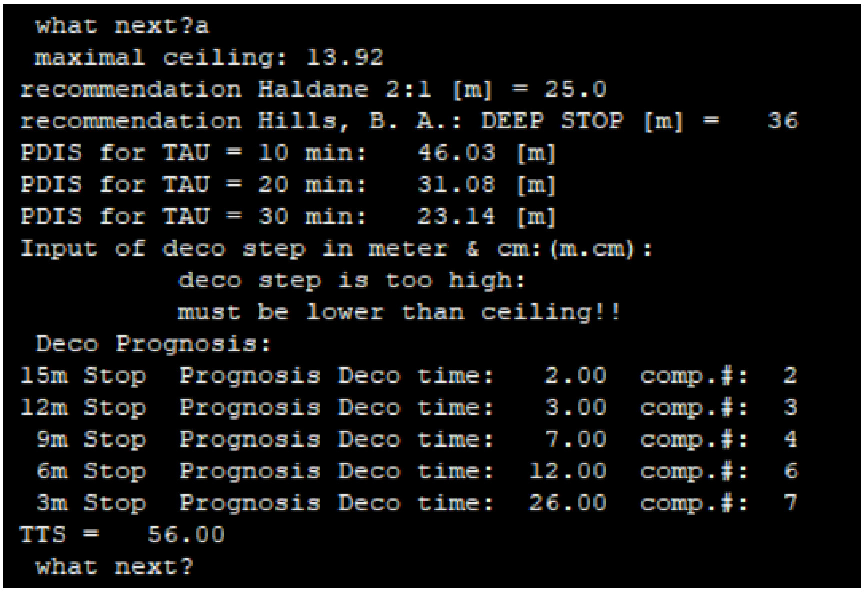
- ➔ 1) Bühlmann / ZH-86 [65], p. 228; air 60 m / 21 min
- ➔ 2) DECO 2000; Air 30 m / 42 min
- ➔ 3) DECO 2000; Altitude (700 – 1-500 m), Air 15 m / 72 min

➔ 4) DECO 92; EAN 36, 33 m / 34 min
➔ 5) comparison of run times & gas volumes
➔ 6) comparison of numerical solutions to the “Trimix Problem“
➔ 7) Delta-Analysis with (old) Subsurface & MultiDeco: Tmx 21/50
➔ 8) Test-Dive: 42 m, 25 , with (old) Subsurface 4.9.6.0
➔ 9) Heliox DIve from [4], p. 35
➔ 10) Comparison of ZH-86, DGUV40, DCIEM and DIVE V 3_09
➔ 11) Comparison of MT92 and DIVE V3_09

The, near-to-perfect, agreement in the scenarios 8) & 9), esp. the 14 profiles from 10) and the even longer dives from 11) is quite nice to acknowledge! But it would be an epic failure to conclude, that these tables or tools would be error-free! The only positive confirmation is, that we, all of us in this club, did make the same errors, or different errors which happen to produce similar outcomes!

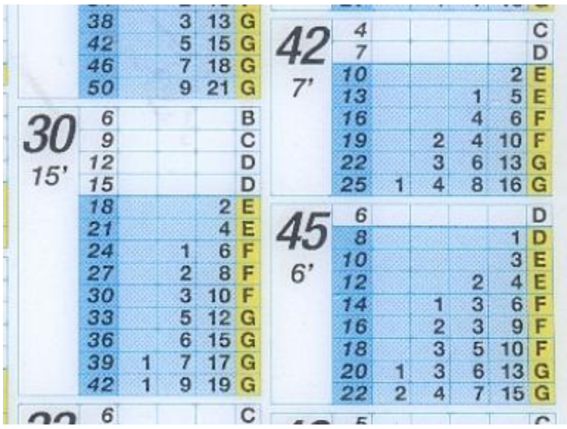
And, what should be perfectly clear: if you dive outside the „protective enveloppe“ (i.e.: > 30 m, > 30 min.) there is not enough substantial data to validate all these tables/tools …

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‘



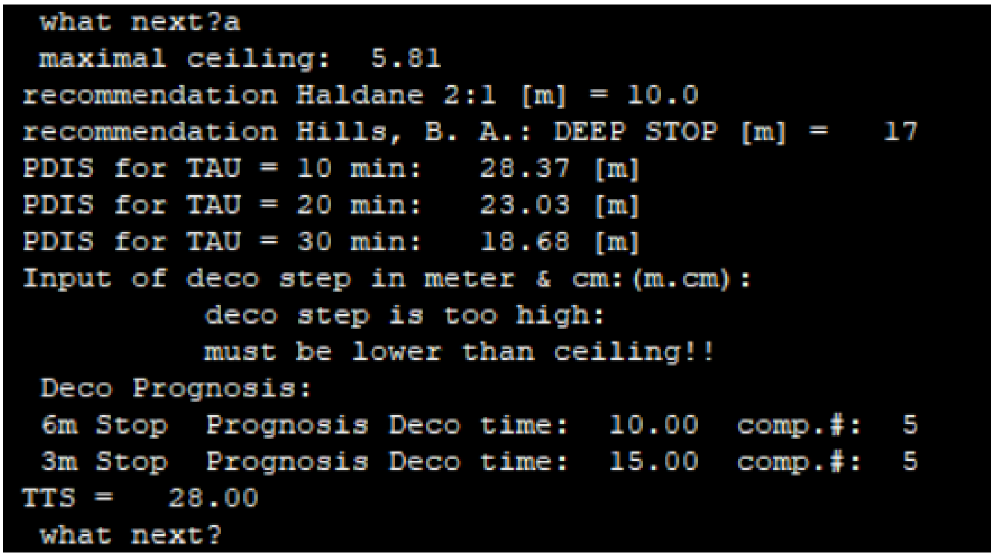
```
 what next?a
 maximal ceiling: 13.92
recommendation Haldane 2:1 [m] = 25.0
recommendation Hills, B. A.: DEEP STOP [m] =   36
PDIS for TAU = 10 min:   46.03 [m]
PDIS for TAU = 20 min:   31.08 [m]
PDIS for TAU = 30 min:   23.14 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
15m Stop  Prognosis Deco time:   2.00  comp.#:  2
12m Stop  Prognosis Deco time:   3.00  comp.#:  3
 9m Stop  Prognosis Deco time:   7.00  comp.#:  4
 6m Stop  Prognosis Deco time:  12.00  comp.#:  6
 3m Stop  Prognosis Deco time:  26.00  comp.#:  7
TTS =   56.00
 what next?
```

2) DECO 2000 [**43**]; air @ 30 m / 42 min:
9 m / 1‘ 6 m / 9‘ 3 m / 19‘



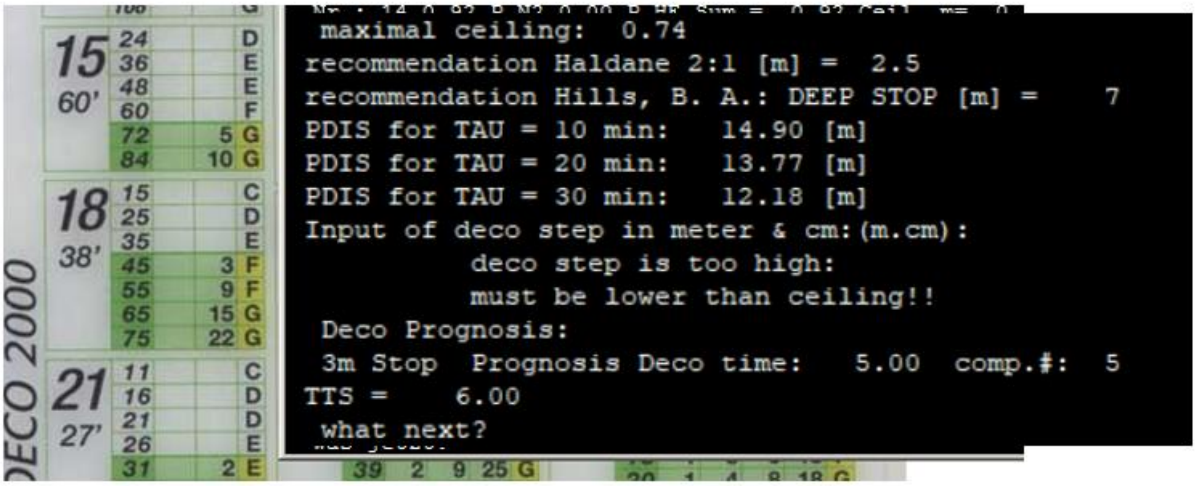
	38		3	13	G
	42		5	15	G
	46		7	18	G
	50		9	21	G
30 15'	6				B
	9				C
	12				D
	15				D
	18			2	E
	21			4	E
	24		1	6	F
	27		2	8	F
	30		3	10	F
	33		5	12	G
	36		6	15	G
	39	1	7	17	G
	42	1	9	19	G
	6				C

42 7'	4					C
	7					D
	10				2	E
	13			1	5	E
	16			4	6	F
	19		2	4	10	F
	22		3	6	13	G
	25	1	4	8	16	G
45 6'	6					D
	8				1	D
	10				3	E
	12			2	4	E
	14		1	3	6	F
	16		2	3	9	F
	18		3	5	10	F
	20	1	3	6	13	G
	22	2	4	7	15	G



```
 what next?a
 maximal ceiling:  5.81
recommendation Haldane 2:1 [m] = 10.0
recommendation Hills, B. A.: DEEP STOP [m] =   17
PDIS for TAU = 10 min:   28.37 [m]
PDIS for TAU = 20 min:   23.03 [m]
PDIS for TAU = 30 min:   18.68 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
 6m Stop  Prognosis Deco time:  10.00  comp.#:  5
 3m Stop  Prognosis Deco time:  15.00  comp.#:  5
TTS =   28.00
 what next?
```

3) <u>DECO 2000 [**43**]; altitude: 700 – 1,500 m, air @ 15 m / 72 min:</u>

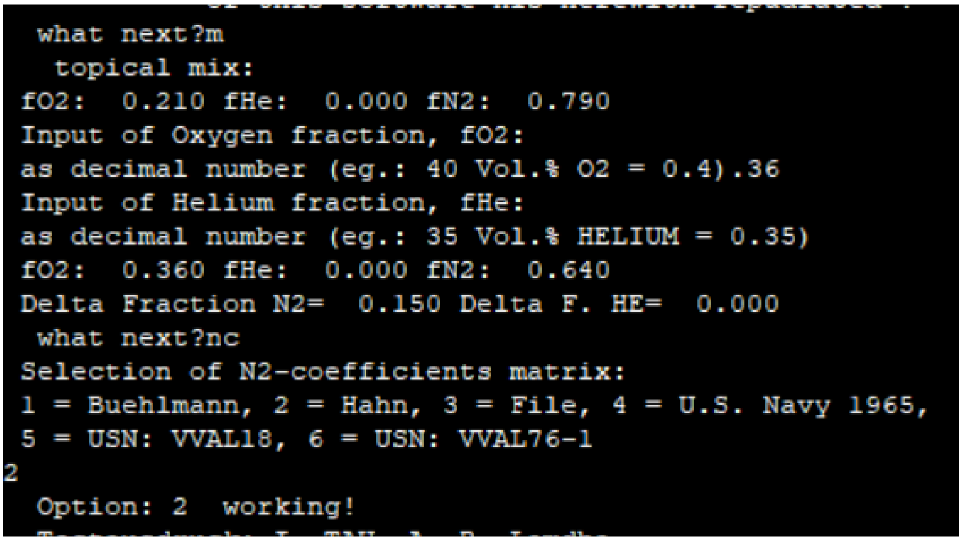


DECO 2000

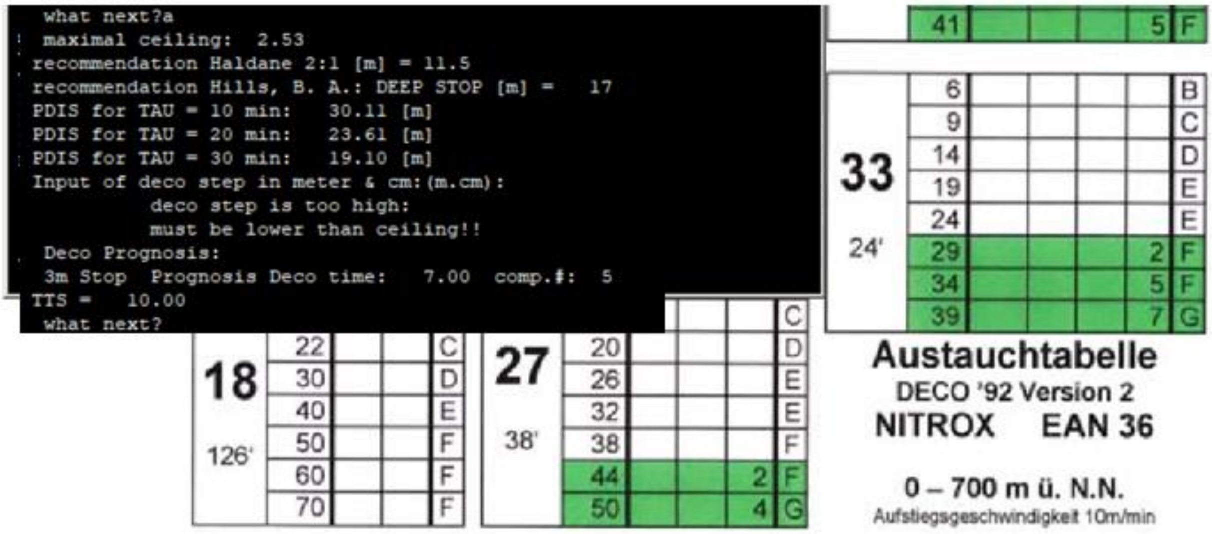
15 60'	24			D
	36			E
	48			E
	60			F
	72		5	G
	84		10	G
18 38'	15			C
	25			D
	35			E
	45		3	F
	55		9	F
	65		15	G
	75		22	G
21 27'	11			C
	16			D
	21			D
	26			E
	31		2	E

```
 maximal ceiling:  0.74
recommendation Haldane 2:1 [m] =  2.5
recommendation Hills, B. A.: DEEP STOP [m] =    7
PDIS for TAU = 10 min:   14.90 [m]
PDIS for TAU = 20 min:   13.77 [m]
PDIS for TAU = 30 min:   12.18 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
 3m Stop  Prognosis Deco time:   5.00  comp.#:  5
TTS =    6.00
 what next?
```

4) <u>DECO 92 [**43**]; EAN 36, 33 m / 34 min:</u>



```
 what next?m
  topical mix:
fO2:   0.210 fHe:   0.000 fN2:   0.790
Input of Oxygen fraction, fO2:
as decimal number (eg.: 40 Vol.% O2 = 0.4).36
Input of Helium fraction, fHe:
as decimal number (eg.: 35 Vol.% HELIUM = 0.35)
fO2:   0.360 fHe:   0.000 fN2:   0.640
Delta Fraction N2=  0.150 Delta F. HE=  0.000
 what next?nc
Selection of N2-coefficients matrix:
1 = Buehlmann, 2 = Hahn, 3 = File, 4 = U.S. Navy 1965,
5 = USN: VVAL18, 6 = USN: VVAL76-1
2
 Option: 2  working!
```



```
 what next?a
 maximal ceiling:  2.53
recommendation Haldane 2:1 [m] = 11.5
recommendation Hills, B. A.: DEEP STOP [m] =   17
PDIS for TAU = 10 min:   30.11 [m]
PDIS for TAU = 20 min:   23.61 [m]
PDIS for TAU = 30 min:   19.10 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
 3m Stop  Prognosis Deco time:   7.00  comp.#:  5
TTS =   10.00
 what next?
```

	41				5	F

33	6					B
	9					C
	14					D
	19					E
	24					E
24'	29				2	F
	34				5	F
	39				7	G

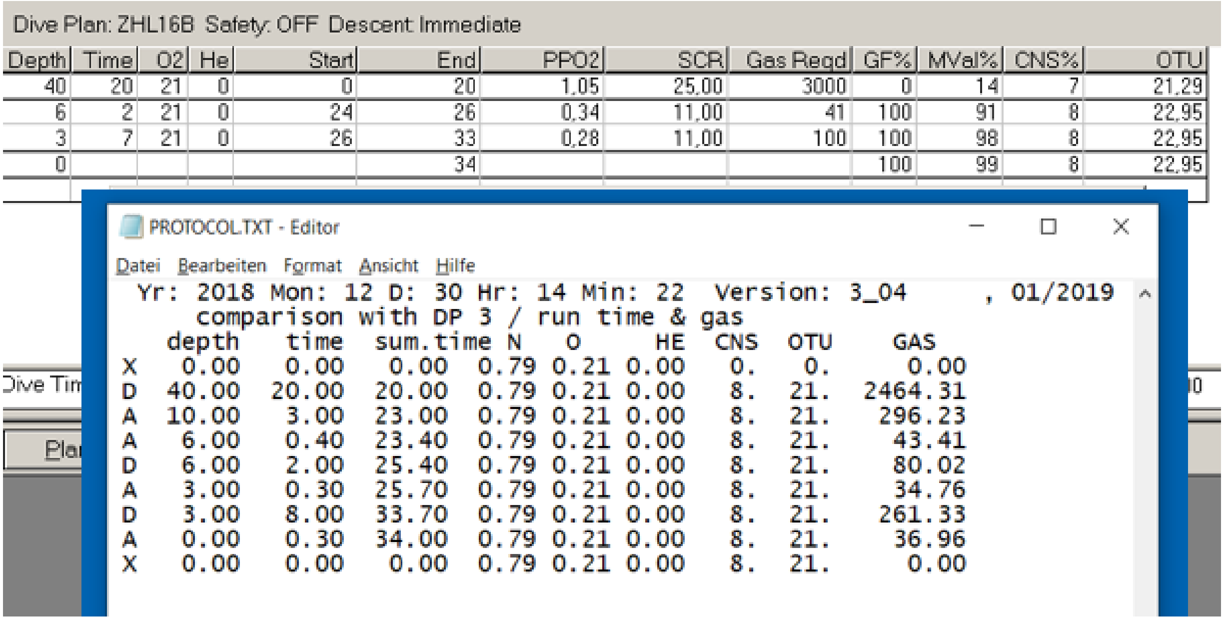
18	22			C
	30			D
	40			E
	50			F
126'	60			F
	70			F

					C
27	20				D
	26				E
	32				E
38'	38				F
	44			2	F
	50			4	G

Austauchtabelle
DECO '92 Version 2
NITROX EAN 36

0 – 700 m ü. N.N.
Aufstiegsgeschwindigkeit 10m/min

5) Comparison of run times & gas volumes



Dive Plan: ZHL16B Safety: OFF Descent Immediate

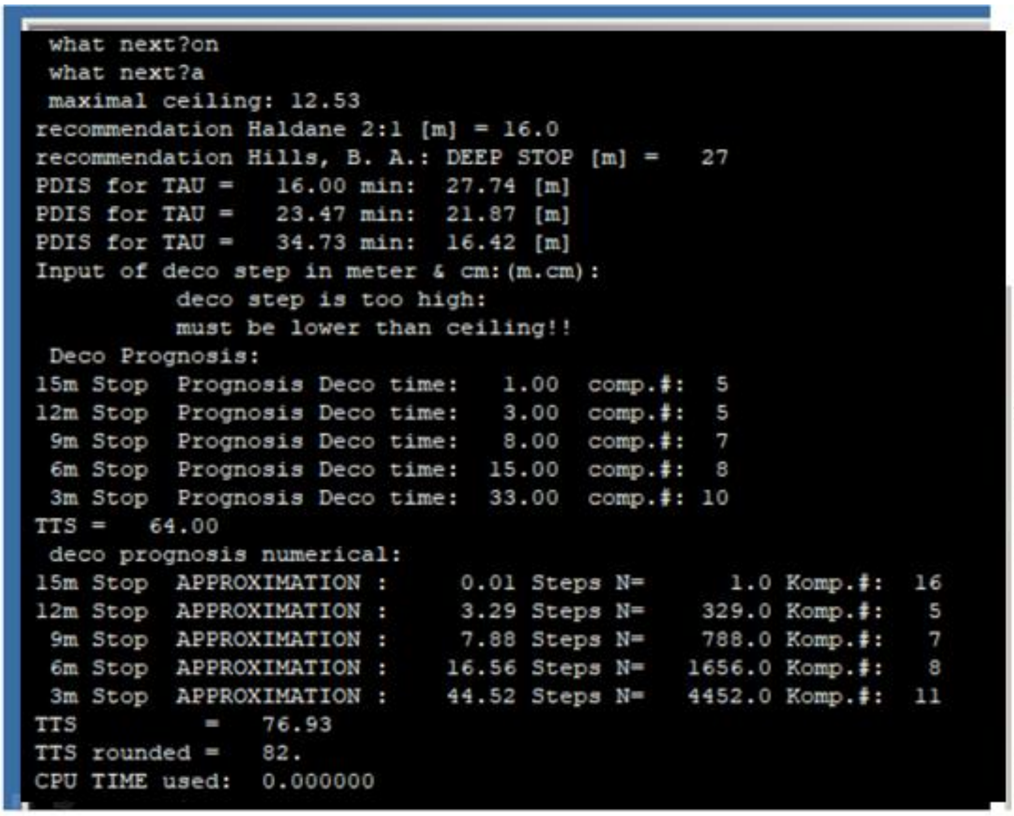
Depth	Time	O2	He	Start	End	PPO2	SCR	Gas Reqd	GF%	MVal%	CNS%	OTU
40	20	21	0	0	20	1.05	25.00	3000	0	14	7	21.29
6	2	21	0	24	26	0.34	11.00	41	100	91	8	22.95
3	7	21	0	26	33	0.28	11.00	100	100	98	8	22.95
0					34				100	99	8	22.95

```
 Yr: 2018 Mon: 12 D: 30 Hr: 14 Min: 22  Version: 3_04     , 01/2019
     comparison with DP 3 / run time & gas
   depth   time   sum.time N    O     HE   CNS  OTU     GAS
X   0.00   0.00   0.00  0.79 0.21 0.00   0.   0.     0.00
D  40.00  20.00  20.00  0.79 0.21 0.00   8.  21.  2464.31
A  10.00   3.00  23.00  0.79 0.21 0.00   8.  21.   296.23
A   6.00   0.40  23.40  0.79 0.21 0.00   8.  21.    43.41
D   6.00   2.00  25.40  0.79 0.21 0.00   8.  21.    80.02
A   3.00   0.30  25.70  0.79 0.21 0.00   8.  21.    34.76
D   3.00   8.00  33.70  0.79 0.21 0.00   8.  21.   261.33
A   0.00   0.30  34.00  0.79 0.21 0.00   8.  21.    36.96
X   0.00   0.00   0.00  0.79 0.21 0.00   8.  21.     0.00
```

You see clearly the different ways of calculation (e.g. water density = 1 to/m^3, 10 m = 1 Bar, etc.) and the weighting of the transit times.

6) Comparison for the numerical solution of the trimix problem

As already described at length in the other references (pls. cf. chapter 45) let's take a Heliox20/80 for various reasons for our standard test dive:



```
 what next?on
 what next?a
 maximal ceiling: 12.53
recommendation Haldane 2:1 [m] = 16.0
recommendation Hills, B. A.: DEEP STOP [m] =   27
PDIS for TAU =    16.00 min:  27.74 [m]
PDIS for TAU =    23.47 min:  21.87 [m]
PDIS for TAU =    34.73 min:  16.42 [m]
Input of deco step in meter & cm:(m.cm):
          deco step is too high:
          must be lower than ceiling!!
 Deco Prognosis:
15m Stop  Prognosis Deco time:   1.00  comp.#:  5
12m Stop  Prognosis Deco time:   3.00  comp.#:  5
 9m Stop  Prognosis Deco time:   8.00  comp.#:  7
 6m Stop  Prognosis Deco time:  15.00  comp.#:  8
 3m Stop  Prognosis Deco time:  33.00  comp.#: 10
TTS =    64.00
 deco prognosis numerical:
15m Stop  APPROXIMATION :    0.01 Steps N=     1.0 Komp.#:  16
12m Stop  APPROXIMATION :    3.29 Steps N=   329.0 Komp.#:   5
 9m Stop  APPROXIMATION :    7.88 Steps N=   788.0 Komp.#:   7
 6m Stop  APPROXIMATION :   16.56 Steps N=  1656.0 Komp.#:   8
 3m Stop  APPROXIMATION :   44.52 Steps N=  4452.0 Komp.#:  11
TTS           =   76.93
TTS rounded =   82.
CPU TIME used:   0.000000
```

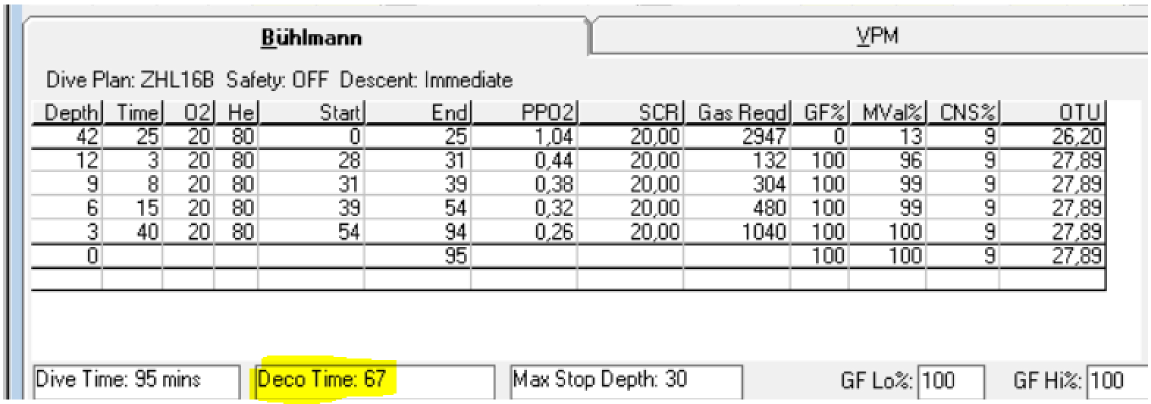
```
* erstes Gas#1 = Hx20/80
...
==== OC Runtime ====
25:12 42.0m Deko:

 42 m  25 '  25.0 ' Gas#1
 12 m   3 '  31.0 '
  9 m   8 '  39.3 '
  6 m  17 '  56.6 '
  3 m  49 ' 105.9 '
  0 m  ---- 106.9 '
TTS = 82 '
CNS = 10%
```

70-1: comparison of numerical solutions

This looks pretty good as the TTSs of the numerical solutions fall **exactly** into place with 82. Once again, if you have another product, chances are, that yours will see something similar to the first TTS (64) …

Source for the tool on the right side: https://ostc-planner.net/wp/

So, here is an example of another product: things start to go terribly wrong (yellow):



Dive Plan: ZHL16B Safety: OFF Descent: Immediate

Depth	Time	O2	He	Start	End	PPO2	SCR	Gas Reqd	GF%	MVal%	CNS%	OTU
42	25	20	80	0	25	1,04	20,00	2947	0	13	9	26,20
12	3	20	80	28	31	0,44	20,00	132	100	96	9	27,89
9	8	20	80	31	39	0,38	20,00	304	100	99	9	27,89
6	15	20	80	39	54	0,32	20,00	480	100	99	9	27,89
3	40	20	80	54	94	0,26	20,00	1040	100	100	9	27,89
0					95				100	100	9	27,89

Dive Time: 95 mins

Deco Time: 67

Max Stop Depth: 30

GF Lo%: 100

GF Hi%: 100

70-2: SNAFU with HELIOX

7) Delta-Analysis with Subsurface & MultiDeco

Just for the fun of it: the old box profile 42 m / 25 min with Trimx 21 / 50 from DIVE (Version 3_07) and Subsurface (Version 4.9.03 11 / 2019) and MultiDeco Version 4.14: looks quite ok, per stage ca. + / - 1 min delta up to max. 2 min, in sum the TTS a little bit more:

Stop Depth [m]/ [min]	**DIVE 3_07 (1)**	**DIVE 3_07 (1a)**	**DIVE 3_07 (2)**	**Sub-surface 4.9.3.0 (1)**	**Sub-surface 4.9.3.0 (1a)**	**Sub-surface 4.9.3.0 (2)**	**MultiDeco 4.14 (1)**	**MultiDeco 4.14 (1a)**	**MultiDeco 4.14 (2)**
12	**1**	**2**	**3**			**1**	**-**	**1**	**1**
9	**4**	**4**	**5**	**3**	**5**	**7**	**3**	**4**	**6**
6	**9**	**10**	**11**	**10**	**11**	**12**	**8**	**10**	**10**
3	**20**	**21**	**26**	**21**	**23**	**29**	**23**	**23**	**25**

TTS [min]	**38**	**41**	**49**	**39**	**44**	**52**	**34**	**41**	**45**
%CNS / OTU			**11** **29**			**11** **34**			**11** **30**

Table 8: Delta-Analysis DIVE vs. Subsurface / MultiDeco

(1): GF 100
(1a): GF 100 + Bühlmann Depth Safety Factor
(2): GF Hi = GF Lo = 93 + Depth Safety Factor

Delta-Analysis: TTS DIVE – TTS Subsurface / TTS DIVE:

- 1 / 38 = - 2,6 %
- 3 / 41 = - 7,3 %
- 3 / 49 = - 6,1%

Delta-Analysis: TTS DIVE – TTS MultiDeco / TTS DIVE:

+ 4 / 38 = + 10,5 %
+ 0 / 41 = 0 %
+ 4 / 49 = + 8,1%

All details & screen shots logfiles etc. there:
https://www.divetable.info/skripte/TMX_50.pdf

8) Test Dive: 42 m, 25 , Luft, with Subsurface 4.9.6.0
source: https://subsurface-divelog.org/

DIVE V 3_11: 9m/2‘, 6m/6‘, 3m/16‘; TTS = 28 min

HINWEIS / WARNUNG: DIES IST EINE NEUIMPLEMENTATION DES BUHLMANN-ALGORITHMUS UND EINE DARAUF BASIERENDE TAUCHGANGSPLANERIMPLEMENTATION, DIE NUR EINER GERINGEN ZAHL VON TESTS UNTERZOGEN WURDE. WIR RATEN DRINGEND, TAUCHGÄNGE NICHT AUSSSCHLIESSLICH AUFGRUND DIESER RESULTATE ZU PLANEN!

Subsurface (4.9.6.0) Plan erstellt am 17.09.20
Runtime: 55 min

	Tiefe	Dauer	Runtime	Gas
↘	42m	2min	2min	**Luft**
→	42m	25min	27min	
↗	9m	4min	31min	
-	**9m**	**1min**	32min	
↗	6m	0min	32min	
-	**6m**	**7min**	39min	

	Tiefe	Dauer	Runtime	Gas
➚	3m	0min	39min	
-	**3m**	**16min**	55min	
➚	0m	0min	55min	

CNS: 10%
OTU: 31

… matches to 100 % !!!

The delta-time per stage is just +/- 1 min;
the delta-sum, over the TTS is 0:
→ (2+6+16) – (1+7+16) / 24 = 0 %;
the delta in the complete run-time is ca. 2 min.:
→ 53 – 55 / 53 < 2 %!
(i.e.: it exceeds the precision of any dive computer …)

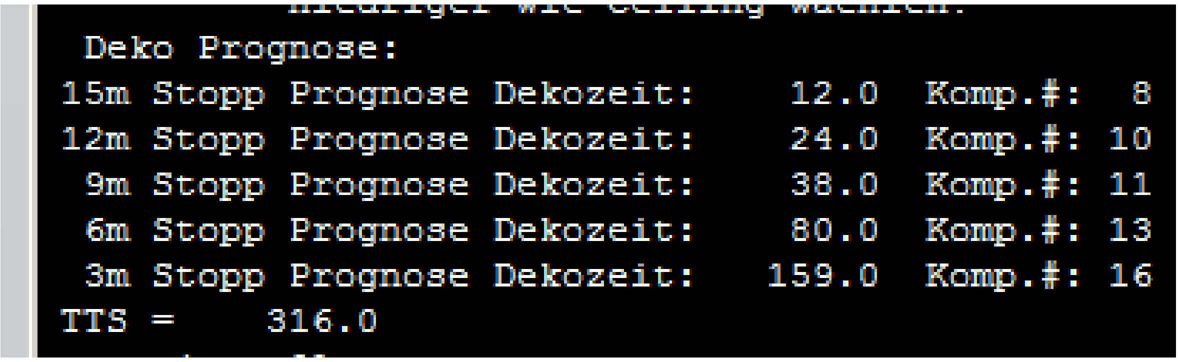
9) The Heliox-Dive from [4], p. 35

This dive is described there as: 4 Bar, Heliox (21/78) and 120 min bottom-time.
With:

„m“, „.21“, „.78“	(Heliox with 1% N_2 contamination)
„nc“, „8“	(the 1983 ZH-L_{12} N2 matrix)
„hc“, „2“	(the 1983 ZH-L_{12} Helium matrix)
„d“, „30.“, „120.“	(the dive parameters from above)

And with:

„a“ we recieved the following output:



```
 Deko Prognose:
15m Stopp Prognose Dekozeit:    12.0  Komp.#:  8
12m Stopp Prognose Dekozeit:    24.0  Komp.#: 10
 9m Stopp Prognose Dekozeit:    38.0  Komp.#: 11
 6m Stopp Prognose Dekozeit:    80.0  Komp.#: 13
 3m Stopp Prognose Dekozeit:   159.0  Komp.#: 16
TTS =     316.0
```

70-3: the HELIOX dive from [4], p. 35

In [4] we see on p. 35 the complete hang-time with the bottom-mix as 316 min.
The first stop depth and the stop time there are identical, the delta-time in the **TTS = 0 min.**
And thus by far better than the precision of any chamber-pressure gauge!

But certainly you could overdo with the agreement: play with „ar“ & „r“, and, as well with „L“, since the ambient pressure at start of this chamber-trials was different in Zürich!

Further details @ **researchgate, or there:**
https://www.divetable.info/skripte/Heliox_30m.pdf DOI: 10.13140/RG.2.2.24608.20482

10) Extended QA, the first … :

https://www.researchgate.net/publication/346317134
features a comparison of: ZH-86, DGUV40, DCIEM and DIVE V 3_09.

We compared 14 (sic: 14!) profiles in these 4 versions. The agreement between DIVE V 3_09 and ZH-86 is maximal!

71 Extended QA, the second …

As well for the fun of it, we put the coefficients of the MT92 (air-)table ca. 02/2021 into D3_09 („NC“; option 12) and then compared with 5 longer profiles: the agreement is nearly perfect!

The details you will find there:

The mapping of a french air diving table (MT92) to a standard Haldane- / Workman- /Schreiner-algorithm, DOI: 10.13140/RG.2.2.34271.38567

72 Appendix B: the ASCII Input/Output Interface

Via the command „F“ (like: filename) the calculated inertgas partial pressures and the dive parameters can be saved as a small ASCII file (Option = „W“ like: write).

In an ascii editor (e.g.: NOTEPAD, EDIT, …) it looks like that:

```
------------------------
 p ambient: 1.013 SAC: 25.0 RQ: 1.000 O2: .200 He: .400 CNS:  10.42 OTU:  26.03 AR:   9.00
VO2: 0.25
 correction:N GFHI=   1.00 GFLO=   1.00 LAST STOP=  3.0 m First Stop =  3.0 m
 depth:  42.00    time:  25.0 max. depth=  42.00 sum. dive time=  25.0
  calculated compartment values:
  No.:  1 2.0085 P N2 2.0245 P He Sum.=  4.0330 Ceil. m=  1.66 Patol:  1.176
  No.:  2 1.8842 P N2 2.0180 P He Sum.=  3.9023 Ceil. m=  6.55 Patol:  1.654
  No.:  3 1.7185 P N2 1.9730 P He Sum.=  3.6915 Ceil. m=  8.22 Patol:  1.818
  No.:  4 1.5447 P N2 1.8549 P He Sum.=  3.3996 Ceil. m=  8.68 Patol:  1.863
  No.:  5 1.3802 P N2 1.6537 P He Sum.=  3.0338 Ceil. m=  7.98 Patol:  1.794
  No.:  6 1.2458 P N2 1.4128 P He Sum.=  2.6586 Ceil. m=  6.25 Patol:  1.625
  No.:  7 1.1348 P N2 1.1541 P He Sum.=  2.2888 Ceil. m=  4.40 Patol:  1.444
  No.:  8 1.0470 P N2 0.9082 P He Sum.=  1.9552 Ceil. m=  2.51 Patol:  1.258
  No.:  9 0.9802 P N2 0.6951 P He Sum.=  1.6753 Ceil. m=  0.71 Patol:  1.082
  No.: 10 0.9373 P N2 0.5456 P He Sum.=  1.4828 Ceil. m=  0.00 Patol:  0.963
  No.: 11 0.9086 P N2 0.4401 P He Sum.=  1.3488 Ceil. m=  0.00 Patol:  0.878
  No.: 12 0.8859 P N2 0.3534 P He Sum.=  1.2393 Ceil. m=  0.00 Patol:  0.812
  No.: 13 0.8679 P N2 0.2825 P He Sum.=  1.1504 Ceil. m=  0.00 Patol:  0.760
  No.: 14 0.8535 P N2 0.2245 P He Sum.=  1.0780 Ceil. m=  0.00 Patol:  0.723
  No.: 15 0.8421 P N2 0.1781 P He Sum.=  1.0202 Ceil. m=  0.00 Patol:  0.691
  No.: 16 0.8332 P N2 0.1410 P He Sum.=  0.9742 Ceil. m=  0.00 Patol:  0.673
```

```
 ------------------------
```

If you put a lot of efforts in your simulated profile you could re-trieve it and re-use it again, say as a starting point for another mission or to compare the results with other products; option = „R“ like read.

If you adapt the outputs of your other desktop deco products into this format, you could use these as an input for DIVE. Thus here is the detailed format description from the original FTN source code from the subroutine FILE in the function-module „READ“:

```
C
C
C
      IF ((ACTION .EQ. "R") .OR. (ACTION .EQ. "r"))THEN
C     OPEN(UNIT=11,ACCESS='SEQUENTIAL',FORM='FORMATTED',
C    +FILE='C:\DIVE\PROT\'//FNAME//'.TXT',
C    +ERR=009,STATUS='OLD')
C
      OPEN(UNIT=15,ACCESS='SEQUENTIAL',
     +FILE='C:\DIVE\PROT\'//FNAME//'.TXT',
     +ERR=009)
C
      READ(15,199,END=009) DUMMY, DUMMY, DUMMY
  199 FORMAT(A1,A1,A47)
C
      READ(15,120) DUMMY, DUMMY, PSTART,
     +DUMMY, DUMMY, AMV,
     +DUMMY, DUMMY, RQ,
     +DUMMY, DUMMY, OZWEI,
     +DUMMY, DUMMY, HELIUM,
     +DUMMY, DUMMY,
     +DUMMY, AR,
     +DUMMY, OXCONS
C
C     +DUMMY, DUMMY, CNS,
C     +DUMMY, DUMMY, OTU,
C     +DUMMY, K_AKTUEL,
C     +DUMMY, POT_AKT
C
  120 FORMAT(A1,A11,F5.3,
     +A1,A5,F4.1,
     +A1,A4,F5.3,
     +A1,A4,F5.3,
     +A1,A4,F4.3,
     +A1,A1,
     +A5,F6.2,
     +A6,F4.2)
C
C     +A1,A5,F7.1,
C     +A1,A5,F7.1,
C     +A11,F8.0,
C     +A9,F7.0)
C
      READ(15,110) DUMMY, DUMMY, CNS,
     +DUMMY, DUMMY, OTU,
     +DUMMY, K_AKTUEL,
     +DUMMY, POT_AKT,
     +DUMMY, PRT
C
 110  FORMAT(A1,A5,F7.1,
     +A1,A5,F7.1,
```

```
     +A11,F8.0,
     +A9,F7.0,
     +A7,F5.1)
C
C     Wenn f(HE) ungleich 0, dann korrigiere f(N2) im COMMON !!!!
C
C
      IF (HELIUM .GT. 0.0) THEN
      NZWO = 1.0 - HELIUM - OZWEI
      ENDIF
C
C
C
      READ(15,130) DUMMY, DUMMY, BKORR, DUMMY, GFHI, DUMMY, GFLO,
     +DUMMY,LASTSTOP, DUMMY, DUMMY, FIRSTOP, DUMMY
  130 FORMAT(A1,A11,A1,A7,F6.2,A7,F6.2,
     +A12,F4.1,A2,A14,F4.1,A2)
C
      READ(15,150) DUMMY, DUMMY, TIEFE, DUMMY, ZEIT, DUMMY, MAXT,
     +DUMMY, GESZ
  150 FORMAT(A1,A7,F6.2,A10,F8.1,A13,
     +F6.2,A17,F8.1)
C
      READ(15,140) DUMMY, DUMMY
  140 FORMAT(A1,A31)
C
C     OBACHT: wegen Compiler Error Message F2730 !!!!!!!!!!!!!
C     wird hier J auf I umkopiert: steht im READ Statement
C     hier an der dritten Stelle statt dem I ebenfalls die
C     Laufvariable J, gibt es beim Compilieren den o.g. Fehler
C
      I=0
      DO 300 J = 1,16
      I=J
      READ(15,201) DUMMY, DUMMY, I, PGEWEBE(J), DUMMY, HEPGEW(J),
     +DUMMY, DUMMY, PGEWSUM(J), DUMMY, CEILING(J), DUMMY, PUTOL(J)
  201 FORMAT (A1,A6,I2,F7.4,A5,F7.4,A5,A7,
     +F7.4,A10,F5.2,A8,F6.3)
  300 CONTINUE
C
      CLOSE(UNIT=11)
      CLOSE(UNIT=15)
      ENDIF
C
C
C
      RETURN
```

The DUMMYs are the „Blanks / Voids“ to put the file pointer to the correct position. With any computer language, like FORTRAN, C, Pascal, etc. you could do that, otherwise a little Excel - Macro, VBA or an XHTML script will do the job as well.

If all this is not possible for you, you could use DIVE again for this job as well as you could „hoof it“ via the following little procedure:

- create yourself a stencil as an edit-format via „F“ and „W“
- open it with your favored editor and write the outputs from your other software in the appropriate fields

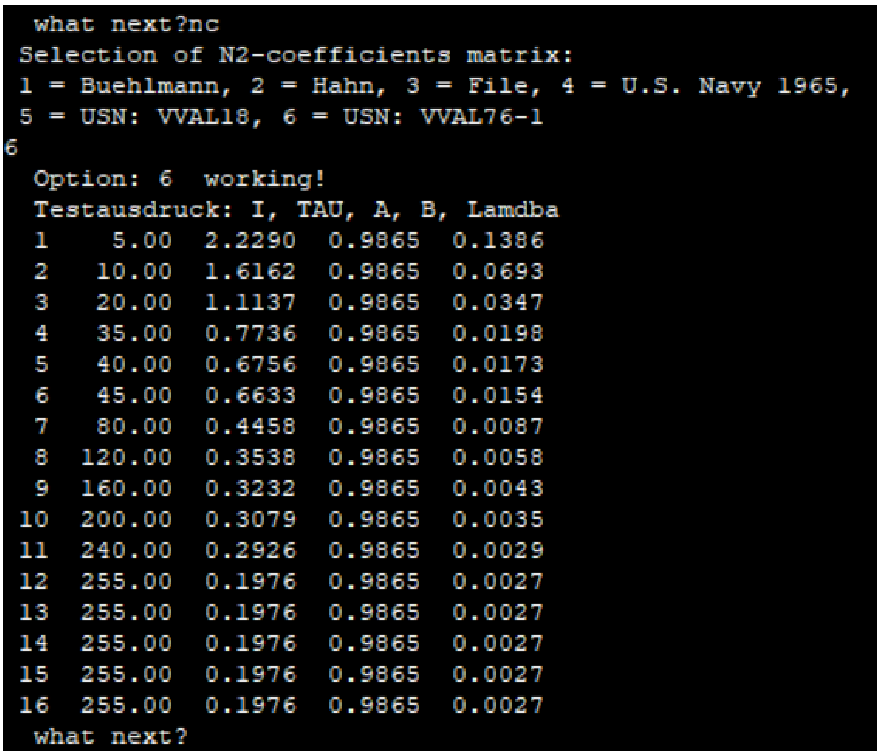
- take care that you do not change the absolute positions in the file and as well the formats
- read in this stencil into DIVE via „F“ and „R“

Hint:
If your desktop deco software provides only 8, 9 or 12 compartments, you have to copy the values from the last one into the rest until the stencil is full unto the 16th.

Attention:
If you use „f“ / „w“ in a sequential order, the data appear as well in the file in the same sequential order so that you could follow it with your run-time.

But if you want to read-in a multi-record file, only the first set is used!

As an example how the trick with filling up works as well with the coefficients matrices, have a look at it via „NC“, say the USN, VVAL76-1, which has only 12 compartments:



```
  what next?nc
 Selection of N2-coefficients matrix:
 1 = Buehlmann, 2 = Hahn, 3 = File, 4 = U.S. Navy 1965,
 5 = USN: VVAL18, 6 = USN: VVAL76-1
6
  Option: 6  working!
  Testausdruck: I, TAU, A, B, Lamdba
  1     5.00  2.2290  0.9865  0.1386
  2    10.00  1.6162  0.9865  0.0693
  3    20.00  1.1137  0.9865  0.0347
  4    35.00  0.7736  0.9865  0.0198
  5    40.00  0.6756  0.9865  0.0173
  6    45.00  0.6633  0.9865  0.0154
  7    80.00  0.4458  0.9865  0.0087
  8   120.00  0.3538  0.9865  0.0058
  9   160.00  0.3232  0.9865  0.0043
 10   200.00  0.3079  0.9865  0.0035
 11   240.00  0.2926  0.9865  0.0029
 12   255.00  0.1976  0.9865  0.0027
 13   255.00  0.1976  0.9865  0.0027
 14   255.00  0.1976  0.9865  0.0027
 15   255.00  0.1976  0.9865  0.0027
 16   255.00  0.1976  0.9865  0.0027
  what next?
```

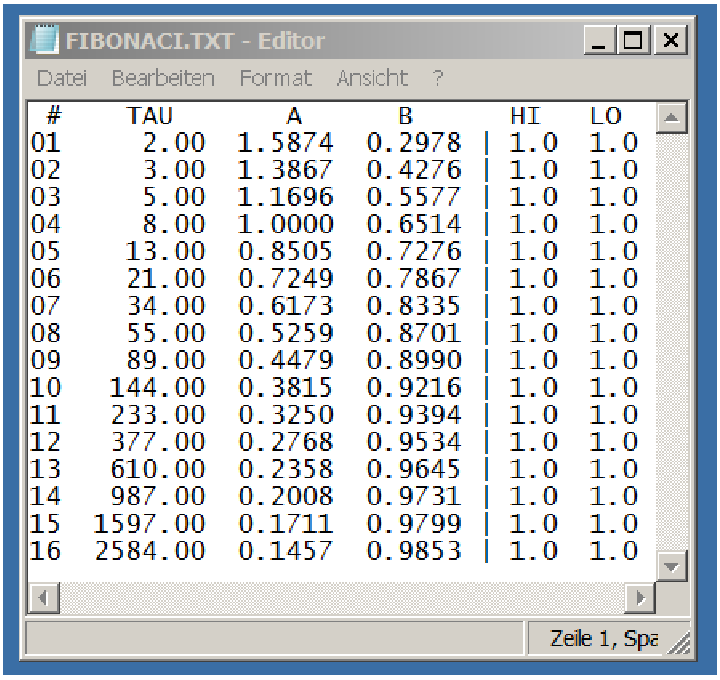
72-1: stencil for a reduced matrix

If you simulate with that, you have as well created the stencil for the compartments with only 12 active lines …

73 Appendix C: the FIBONACCI coefficients-matrix

To play a little bit around there is this FIBONACI.TXT, a coefficients matrix built according to the rule of the famous italian mathematician, Leonardo of Pisa, known as Fibonacci. The rule is, that a number is just the sum of its immediate 2 pre-decessors: 0,1,1,2,3,5…. .

We take this as the HT of the fictiticious spectrum of compartments, so 0 does not make any sense for a HT and the Buehlmann-Hahn algorithm diverges around 1. Thus we start for the fun of it at 2:



```
 #      TAU       A       B       HI    LO
01      2.00  1.5874  0.2978 |  1.0   1.0
02      3.00  1.3867  0.4276 |  1.0   1.0
03      5.00  1.1696  0.5577 |  1.0   1.0
04      8.00  1.0000  0.6514 |  1.0   1.0
05     13.00  0.8505  0.7276 |  1.0   1.0
06     21.00  0.7249  0.7867 |  1.0   1.0
07     34.00  0.6173  0.8335 |  1.0   1.0
08     55.00  0.5259  0.8701 |  1.0   1.0
09     89.00  0.4479  0.8990 |  1.0   1.0
10    144.00  0.3815  0.9216 |  1.0   1.0
11    233.00  0.3250  0.9394 |  1.0   1.0
12    377.00  0.2768  0.9534 |  1.0   1.0
13    610.00  0.2358  0.9645 |  1.0   1.0
14    987.00  0.2008  0.9731 |  1.0   1.0
15   1597.00  0.1711  0.9799 |  1.0   1.0
16   2584.00  0.1457  0.9853 |  1.0   1.0
```

73-1: FIBONACCI coefficients-matrix

Well, so what? This is just to show that a spectrum of HT can be purely at random but produces sensible deco prognoses anyway, even if these used HT do not cover real physiologic sites. And, as the icing on the cake: HTs of, say 900 min and beyond are representing a minor, if not to say, non-existent perfusion and thus zero delivery of oxygen… So, these compartments would be of a type „rotten branch" … Ok, well you could argue, that this is a situation when bubbles arise through decompression and thus block a vessel. So to say you have simulated a „bubble model" by pure perfusion!

How do you play with it?

- Copy the file FIBONACI.TXT to C:\DIVE\PROT
- Maybe you copy it as well to a back-up destination
- Re-name it to: N2COEFF.TXT
- Read that in via „NC" and option „3"
- check with the control output if everything is ok, and:
- go for it …
- Have Fun!

1 Appendix D: Overview on the used sources

The numbers in square brackets [xyz] are related to the respective entry under:

https://www.divetable.eu/BOOKS/index_e.htm

➔ **ZH-L:**

- [4] Dekompression - Dekompressionskrankheit, A. A. Bühlmann, Springer, 1983, ISBN 3-540-12514-0
- [5] Tauchmedizin (Barotrauma, Gasembolie, Dekompression, Dekompressionskrankheit) A. A. Bühlmann, Springer, 1993, ISBN 3-540-55581-1
- [65] "Tauchmedizin.", Albert A. Bühlmann, Ernst B. Völlm (Mitarbeiter), P. Nussberger; 5. Auflage in 2002, Springer, ISBN 3-540-42979-4

➔ **VPM and other models:**

- AMC, Amsterdam, 03/2018: International Symposion on 21.st Century Decompression Theory; Dual Phase Decompression Theory and Bubble Dynamics, available at:
- https://www.divetable.info/skripte/Bubble_Dynamics_02.pdf
- „Decompression Sickness“, Hills, B.A [102]

➔ **Dive Tables: USN, NOAA, DCIEM, Deco2000, MT92:**

- NOAA Nitrox / EANx of 2017: https://www.divetable.info/workshop/194_EAN.pdf resp.: [194], [149], [48]
- USN of 2016: https://www.divetable.info/workshop/USN_Rev7_Tables.pdf
- DCIEM: https://www.divetable.eu/p125936.pdf
- Deco2000: [43]
- 110 Years of History of Diving Tables: https://dx.doi.org/10.13140/RG.2.2.32813.03042
- The french Tables MT 92, Ministere du Travail 1992: https://www.legifrance.gouv.fr/loda/id/JORFTEXT000000690963/

- And, as well:

  https://sneti.eu/wp-content/uploads/2020/06/5-Annexes-Arr%C3%AAt%C3%A9-Mention-A-2019-TABLES-dae_20190524_0003_0001.pdf

- And, an analysis:
- The mapping of a french air diving table (MT92) to a standard Haldane- / Workman- /Schreiner-algorithm; **DOI: 10.13140/RG.2.2.34271.38567**

➔ **Ox-Tox, %CNS, OTU etc.:**

- Hamilton, R.W., Kenyon, D.J., Peterson, R. E., Butler, G.J., Beers, D.M., 1988 May, Repex: Development of repetitive excursions, surfacing techniques, and oxygen procedures for habitat diving, NURP Technical Report 88-1A, Rockwell M.D., U.S. DoD
- The manuals for the pros: [167], [168], [171], [193]
- [182], Donald, Kenneth (1992) Oxygen and the diver, SPA Ltd, ISBN 1 85421 176 5

➔ **K-Index:**

- Arieli, R., A. Yalov, and A. Goldenshluger: Modeling pulmonary and CNS O2 toxicity and estimation of parameters for humans. J Appl Physiol 92: 248–256, 2002; 10.1152/ japplphysiol.00434.2001

- Arieli R. Calculated risk of pulmonary and central nervous system oxygen toxicity: a toxicity index derived from the power equation. Diving and Hyperbaric Medicine. 2019 September 30;49(3):154–160 doi: 10.28920/dhm49.3.154-160. PMID:31523789

- Aviner B, Arieli R and Yalov A (2020) Power Equation for Predicting the Risk of Central Nervous System Oxygen Toxicity at Rest. Front. Physiol. 11:1007.doi: 10.3389/fphys.2020.01007

- Arieli, R., Shochat, T., and Adir, Y. (2006). CNS toxicity in closed-circuit oxygen diving: symptoms reported from 2527 dives. Aviat. ~~Space Environ. Med. 77~~, 526–532

- Wingelaar TT, van Ooij P-JAM and van Hulst RA (2017) Oxygen Toxicity and Special Operations Forces Diving: Hidden and Dangerous. Front. Psychol. 8:1263. doi: 10.3389/fpsyg.2017.01263

➔ ESOT
On the calculation of the new oxygen exposure indices (06.06.2023) and all the references therein
https://dx.doi.org/10.13140/RG.2.2.14400.92169

➔ **PrT Criterium (Hempleman):**

- British Department of Energy, #TA /93/22/249 (1989)
- Lambertsen CJ et al.: Development of Decompression Procedures“ EBSDC Report 7-28-1992, Seite 11)
- [158] Shilling, C. W. Carlston, C.B. Mathias, R.A (1984) The Physician's Guide to Diving Medicine, Plenum Press, N.Y., ISBN-13: 978-1-4612-9663-8, ab S. 251

➔ **Errors in Tables:**

- Ed Thalmann, NEDU Report 13-83
- NEDU TR 09-05 / TA-8-20, p. 1 & 5

➔ **DAN, DSG, DSL etc.:**

- [170] Balestra, Constantino; Germonpre, Peter (ed.), The Science of Diving: Things your instructor never told you (2015) Lambert Academic Publishing, ISBN: 978-3-659-66233-1

➔ **Altitude Diving:**

- https://www.divetable.info/skripte/Altitude_Diving.pdf
- https://www.divetable.info/skripte/Altitude_Diving_II.pdf

- https://www.divetable.info/skripte/Altitude_Diving_III.pdf
- https://www.divetable.info/skripte/Altitude_Diving_IV.pdf
- [151] Wienke, B.R. (1993) Diving above Sea Level, BPC, ISBN 0-941332-30-6;
- And:
- [183], [185], [186], [187].

➔ Isobaric Counterdiffusion (ICD):

- D. J. Graves, J. Idicula, C. J. Lambertsen and J. A. Quinn. Bubble Formation in Physical and Biological Systems: A Manifestation of Counterdiffusion in Composite Media, Science 179 (4073), 582-584. (February 9, 1973)
- Strauss R.H., Kunkle T. D.: Isobaric Bubble Growth: A Consequence of Alterimg Atmospheric Gas. Science, Vol. 186, p. 443 – 444, 1974
- LAMBERTSEN, C. J., AND J. IDICULA. A new gas lesion syndrome in man, induced by "isobaric gas counterdifusion." J. Appl. Physiol. 39(3) : 434-443. 1975
- Hunter, TS Neuman and RF Goad (August 26, 1977), BG D'Aoust, KH Smith, HT Swanson, R White, CA Harvey, WL, Venous gas bubbles: production by transient, deep isobaric Counterdiffusion of helium against nitrogen, Science 197 (4306), 889-891.
- UHMS workshop #22, 1979: Isobaric Inert Gas Counterdiffusion
- SAFE INNER EAR INERT GAS TENSION FOR SWITCH FROM HELIOX TO AIR BREATHING AT 100 FSW DURING DECOMPRESSION, Doolette DJ, Gerth WA, Gault KA, Murphy FG, Navy Experimental Diving Unit, Panama City, FL. ASM 2012, Session F117

➔ Grahams Law, Helium-Penalty:

- D'Aoust, B.G., K. H. Smith, H.T. Swanson, R. White, L. Stayton, and J. Moore. 1979, Prolonged bubble production by transient isobaric counter-equilibration of helium against nitrogen. Undersea Biomed Res. 6(2): 109 -125)
- Doolette DJ, Upton RN and Grant C. (2005). Perfusion-diffusion compartmental models describe cerebral helium kinetics at high and low cerebral blood flows in sheep. J Physiol. 563: 529–539
- David J. Doolette , Richard N. Upton , Cliff Grant Journal of Applied Physiology. Published 1 March 2015 Vol. 118 no. 5, 586-594 DOI: 0.1152/japplphysiol.00944.2014: Altering blood flow does not reveal differences between nitrogen and helium kinetics in brain or in skeletal miracle in sheep

➔ Oxygen Correctionfactors:

- Role of oxygen in the production of human decompression sickness; Weathersby, Hart, Flynn, Walker; JAP 63(6): 2380 – 2387, 1987
- Inspired Oxygen pressure may have unexpected Effects on Inert Gas Exchange; Lundgren, Anderson, Nagasawa, Olszowka, Norfleet; Proceedings of the 40th UHMS workshop, p. 205 – 211, 1989
- Tikuisis P, Nishi R Y. Role of Oxygen in a Bubble Model for predicting Decompression Illness,DCIEM No. 94-04, January 1994
- Probabilistic models of the role of oxygen in human decompression sickness; Parker, Survanshi, Massell, Weathersby; JAP 84(3): 1096 – 1102, 1998

- Lillo, R. S., and E. C. Parker. Mixed-gas model for predicting decompression sickness in rats. J Appl Physiol 89: 2107–2116, 2000

➔ **Coefficients oft he Perfusions-Models:**
- Workman, Robert D. "Calculation of Decompression Tables for Nitrogen-Oxygen and Helium-Oxygen Dives," Research Report 6-65, U.S. Navy Experimental Diving Unit, Washington, D.C. (26 May 1965)
- Hempleman, H.V. „British decompression theory and practice", in: Bennet, P.B., Elliot, D.H.:"The Physiology and Medicine of Diving and Compressed Air Work", 1st ed., Bailliere, Tindall and Cassell, London 1969
- Schreiner, H.R., and Kelley, P.L. "A Pragmatic View of Decompression," Underwater Physiology Proceedings of the Fourth Symposium on Underwater Physiology, edited by C.J. Lambertsen. Academic Press, New York, (1971) pp. 205-219
- Kidd, D.J., R.A. Stubbs and R.S. Weaver „Comparative approaches to prophylactic decompression", in: Lambertsen, C.J.: "Underwater Physiology, Proceedings of the Fourth Symposium on Underwater Physiology", Academic Press, New York 1971.

➔ **USN NEDU Technical Reports:**
- VVAL76: NEDU TR 03-2009, D-1
- und: TR 09-2007, Appendix B-1 & C-1
- VVAL18 & VVAL 18-1: NEDU TR 12-2003, S. 32
- and: NEDU Report 1-84, p. 14
- VVAL 79: TA 10-12, NEDU TR 12-01, MAR 2012, p. 11

➔ **TA:**
- „Accounting for Cold Water Effects in a Decompression Algorithm", Sergio Angelini in: Lang, M.A. and M.D.J. Sayer (eds.) 2007: Proceedings of the International Polar Diving Workshop. Svalbard, March 15-21, 2007. Smithsonian Institution, Washington, DC. 213 p. 55 – 62)

➔ **W:**
- Dick APK, Vann RD, Mebane GY, Feezor MD. Decompression induced nitrogen elimination Undersea Biomed. Res. 1984; 11(4): 369 – 380;
- Doolette DJ, Gerth WA, Gault KA. Probabilistic Decompression Models With Work-Induced Changes In Compartment Gas Kinetic Time Constants Navy Experimental Diving Unit, Panama City, FL, USA; in: UHMS Annual Scientific Meeting, St. Pete Beach, Florida, June 3-5, 2010, Session A6

➔ **RL:**

- The Model for the R/L Shunt from A.A. Bühlmann in [65] on p. 123
- AND:
- https://dx.doi.org/10.13140/RG.2.2.23856.74245

➔ Doppler Measurements after "NDL" dives:

- Andrew Pilmanis, ONR; and:
- Pilmanis AA. Intravenous gas emboli in man after compressed air ocean diving Contract Report, N00014-67-A-0269-0026. Washington, D.C.: Office of Naval Research, 1976
- Proc. of Dive Computer workshop, AAUS, 1988, S. 177; and:
- [8], S. 40.

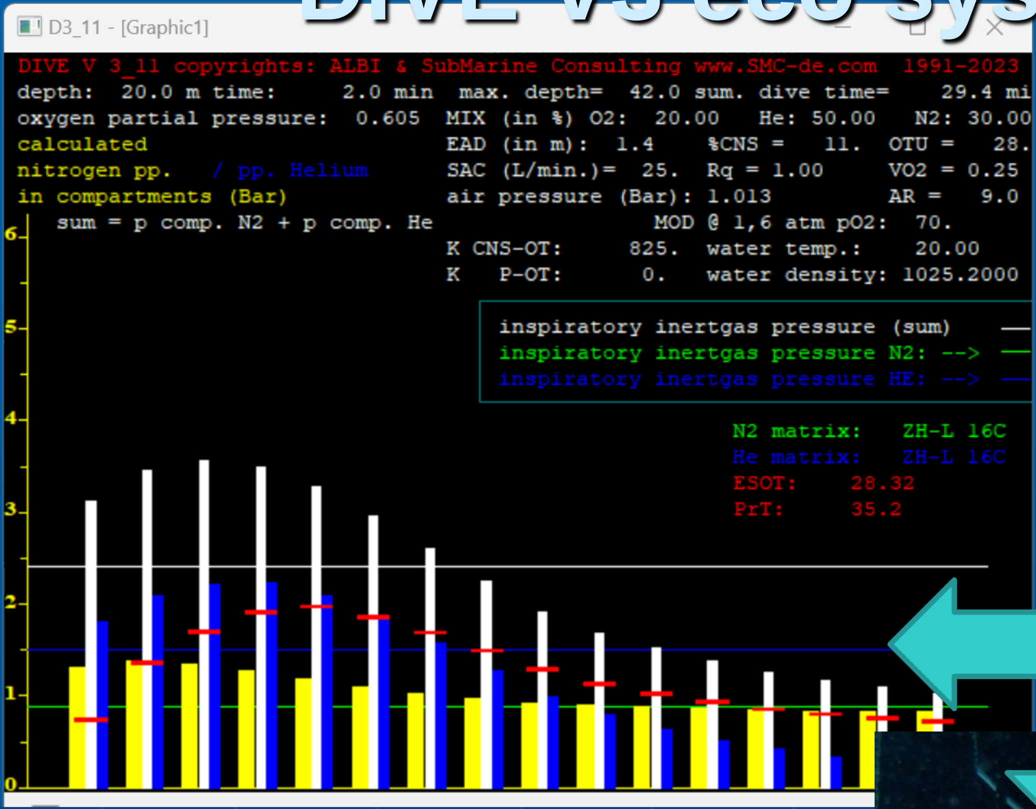
➔ COMEX Procedure:

- webpage: www.comex.fr, as well:
- Source: CBM-D-19-00911
- Bernard Gardette:
- THEORIE GENERALE UNIFIEE DE LA DECOMPRESSION; Directeur Scientifique COMEX November 2009, BG/sc-060/09

➔ SAT Procedures:

- From the United States Navy Diving Manuals
- USN old: 1991, p. 12-42
- USN new: 2018, Table 13-9

DIVE V3 eco system



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2023
depth:  20.0 m time:      2.0 min  max. depth=  42.0 sum. dive time=    29.4 mi
oxygen partial pressure:  0.605  MIX (in %) O2:  20.00   He: 50.00   N2: 30.00
calculated                       EAD (in m):  1.4     %CNS =    11.  OTU =   28.
nitrogen pp.   / pp. Helium      SAC (L/min.)=  25.   Rq = 1.00      VO2 = 0.25
in compartments (Bar)            air pressure (Bar): 1.013           AR =    9.0
   sum = p comp. N2 + p comp. He                MOD @ 1,6 atm pO2:  70.
                                 K CNS-OT:     825.  water temp.:     20.00
                                 K    P-OT:      0.  water density: 1025.2000

                                    inspiratory inertgas pressure (sum)
                                    inspiratory inertgas pressure N2: -->
                                    inspiratory inertgas pressure HE: -->

                                                     N2 matrix:   ZH-L 16C
                                                     He matrix:   ZH-L 16C
                                                     ESOT:     28.32
                                                     PrT:      35.2
```

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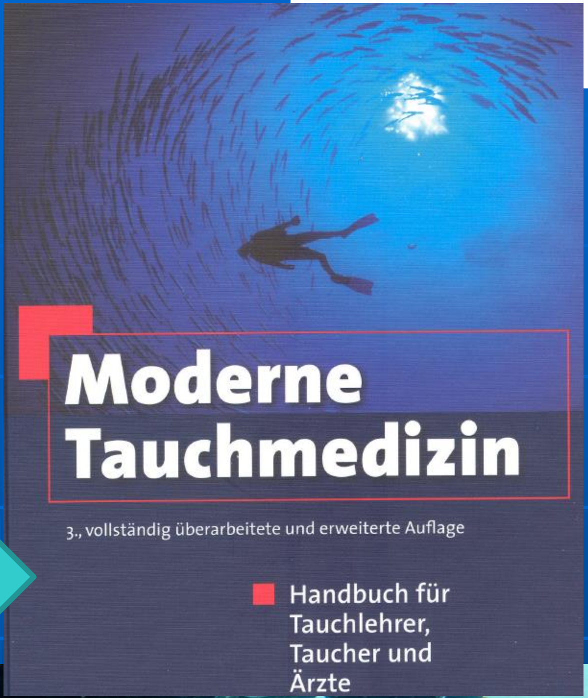
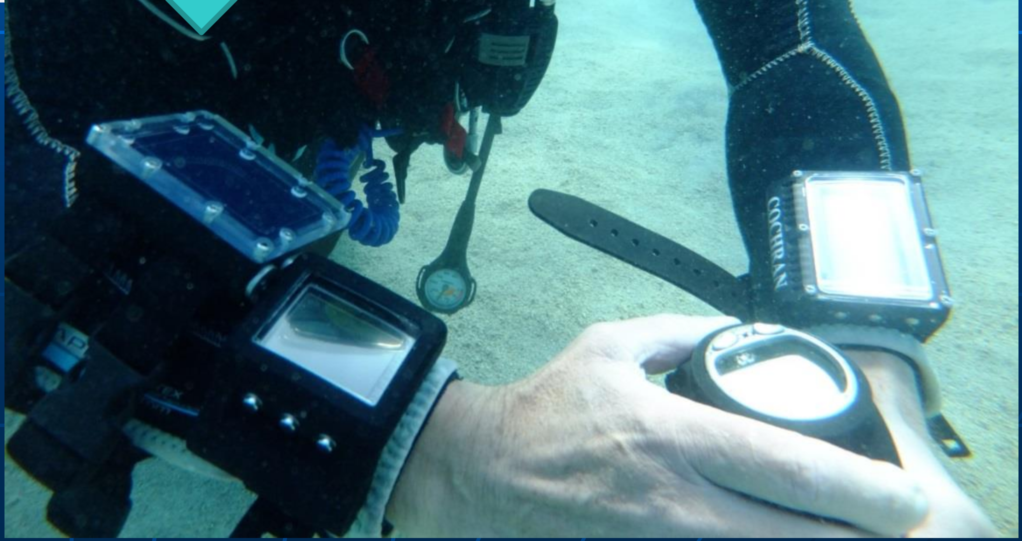


Moderne Tauchmedizin

3., vollständig überarbeitete und erweiterte Auflage

Handbuch für Tauchlehrer, Taucher und Ärzte



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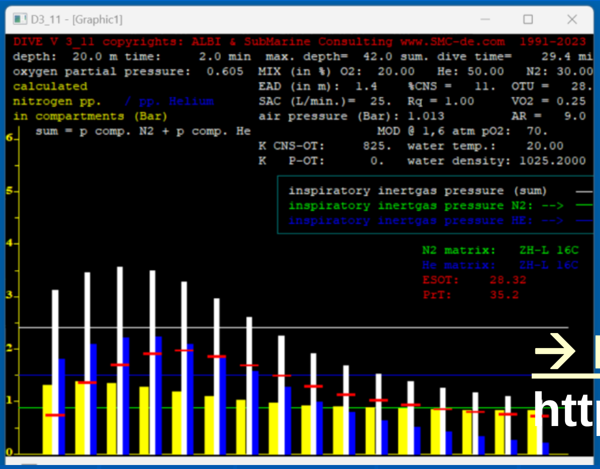
DIVE V3 eco system



```
DIVE V 3_11 copyrights: ALBI & SubMarine Consulting www.SMC-de.com  1991-2023
depth:  20.0 m time:     2.0 min  max. depth=  42.0 sum. dive time=    29.4 mi
oxygen partial pressure:  0.605  MIX (in %) O2:  20.00   He: 50.00   N2: 30.00
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in compartments (Bar)            air pressure (Bar): 1.013         AR =   9.0
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                                 K CNS-OT:     825.  water temp.:    20.00
                                 K   P-OT:       0.  water density: 1025.2000

                                      inspiratory inertgas pressure (sum)
                                      inspiratory inertgas pressure N2: -->
                                      inspiratory inertgas pressure HE: -->

                                                        N2 matrix:   ZH-L 16C
                                                        He matrix:   ZH-L 16C
                                                        ESOT:    28.32
                                                        PrT:     35.2
```

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Moderne Tauchmedizin

3., vollständig überarbeitete und erweiterte Auflage

Handbuch für Tauchlehrer, Taucher und Ärzte

→ DIVE Desktop Deco Software, Version 3_11:
https://www.divetable.info/DIVE_V3/V3e/index.htm

→ THE (!) „deco workshop“:
https://www.divetable.info/workshop_e.htm

→ Modern Diving Medicine (in german):
https://www.divetable.eu/BOOKS/205.pdf

→ The little virtual dive computer museum:
https://www.divetable.info/museum_e.htm

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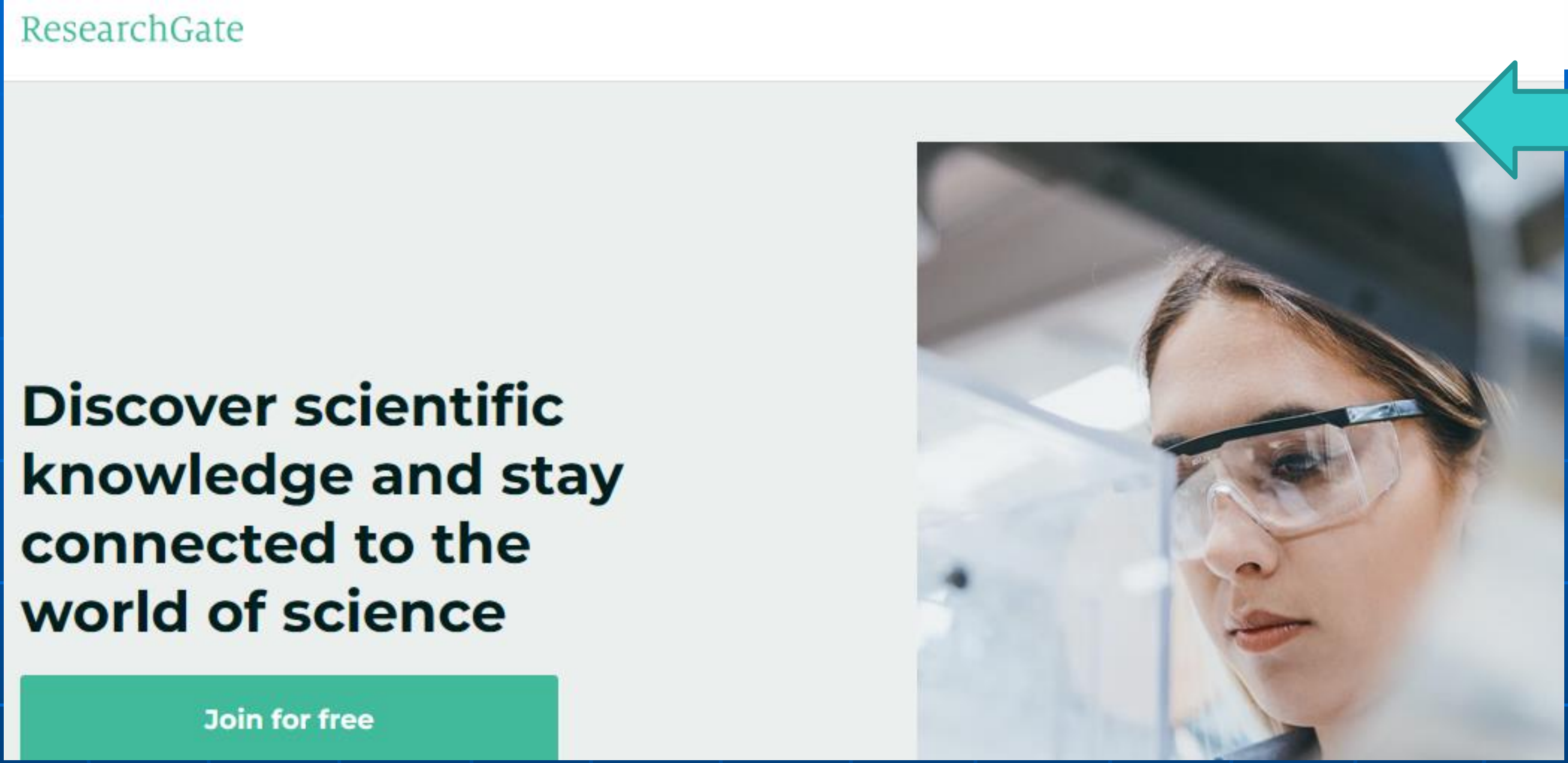
DIVE V3 eco system



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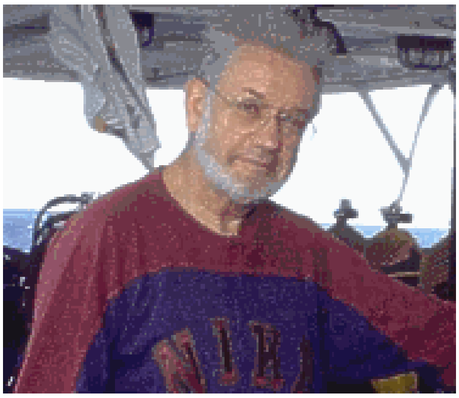
In Memoriam

… for three of my dear friends and colleagues. It is Dr. Max „Maxe“ Hahn, Dr. Bernd „Aschi“ Aspacher and „Big Ben“, PADI Course Director Ben Walzinger:



Max told me a lot about his Deco-, Micro- and whatever –Brains, incl. the therefore used a- and b- coefficients long before they hit the market. This yields as well for his last air-table, the Deco2000. Bernd was one of the first PADI instructors who enjoyed here in Europe in the beginning of the 90’s my brand new distinctive PADI-specialty „Dive Computer & Dive Tables“. Both were physicists and dedicated instructors: both died during tragical diving accidents.

Ben joined me here in Esslingen in 2002 and enjoyed as well this particular PADI specialty. Then, in 2006, we had our famous „deco week“ in his dive center in Phuket / Thailand.
In 2018 Ben never returned from a solo-dive.