AD-751 027

SYSTEMATIC GUIDE TO DECOMPRESSION SCHEDULE CALCULATIONS

William R. Braithwaite

Navy Experimental Diving Unit
Washington, D. C.

15 July 1972

AD751027

DEPARTMENT OF THE NAVY · SHIP SYSTEMS COMMAND

DEPARTMENT OF THE NAVY · EXPERIMENTAL DIVING UNIT

Navy Experimental Diving Unit

EXPERIMENTAL DIVING UNIT
UNITED STATES NAVY

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) OFFICER IN CHARGE NAVY EXPERIMENTAL DIVING UNIT WASH. NAVY YARD, WASHINGTON, D.C. 20390	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SYSTEMATIC GUIDE TO DECOMPRESSION SCHEDULE CALCULATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final

5. AUTHOR(S) (First name, middle initial, last name)

William R. Braithwaite, LCDR, MC, USNR

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
15 July 1972	~~18~~ 21	1

8a. CONTRACT OR GRANT NO. 62755N b. PROJECT NO. MF 12.524.014-9013DA9K c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Experimental Diving Unit Report 11-72 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	NAVY EXPERIMENTAL DIVING UNIT WASHINGTON NAVY YARD WASHINGTON, D.C. 20390

13. ABSTRACT

This report is designed to be used in conjunction with Workman's presentation of the theoretical basis for the calculation of decompression schedules, EDU Report No. 6-65, to clarify the definitions and simplify the calculation procedure. An attempt has been made to explain verbally and graphically the basic concepts in areas known to be difficult for students of Workman's method. The report includes a step-by-step program designed to lead one through the calculations with a minimum of confusion, and a discussion of methods for shortening the time involved. The necessary tables and worksheet used in the calculations are also included.

I-B

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Diving						
Decompression						
Computation						

Experimental Diving Unit Report
11-72

SYSTEMATIC GUIDE
TO
DECOMPRESSION SCHEDULE CALCULATIONS

W. R. BRAITHWAITE, LCDR, MC, USNR

Submitted:	Reviewed:	Approved:
W. R. Braithwaite LCDR MC USN Medical Research Officer	W. B. Wright LCDR MC USN Acting Senior Medical Research Officer	J. J. Coleman CDR USN Officer in Charge

I-A

ABSTRACT

This report is designed to be used in conjunction with Workman's presentation of the theoretical basis for the calculation of decompression schedules, EDJ Report No. 6-65, to clarify the definitions and simplify the calculation procedure. An attempt has been made to explain verbally and graphically the basic concepts in areas known to be difficult for students of Workman's method. The report includes a step-by-step program designed to lead one through the calculations with a minimum of confusion, and a discussion of methods for shortening the time involved. The necessary tables and worksheet used in the calculations are also included.

CONTENTS

Preceding page blank

I. INTRODUCTION

Many students find the hand calculation of decompression tables difficult, even if the basic concepts are understood, because the arithmetic manipulations appear intricate and cumbersome as presented. The enclosed explanation includes a step-by-step program designed to simplify these calculations. It adheres as closely as possible to the method, symbols, and worksheet presented by Workman[1].

II. DEFINITIONS

A short definition of each variable is included in the program (long version) to keep the user aware of what he is dealing with and to further his understanding. In addition to the more detailed explanations to be found in Workman's original report, you may find the graphical correlation of parameters in figure 1 useful.

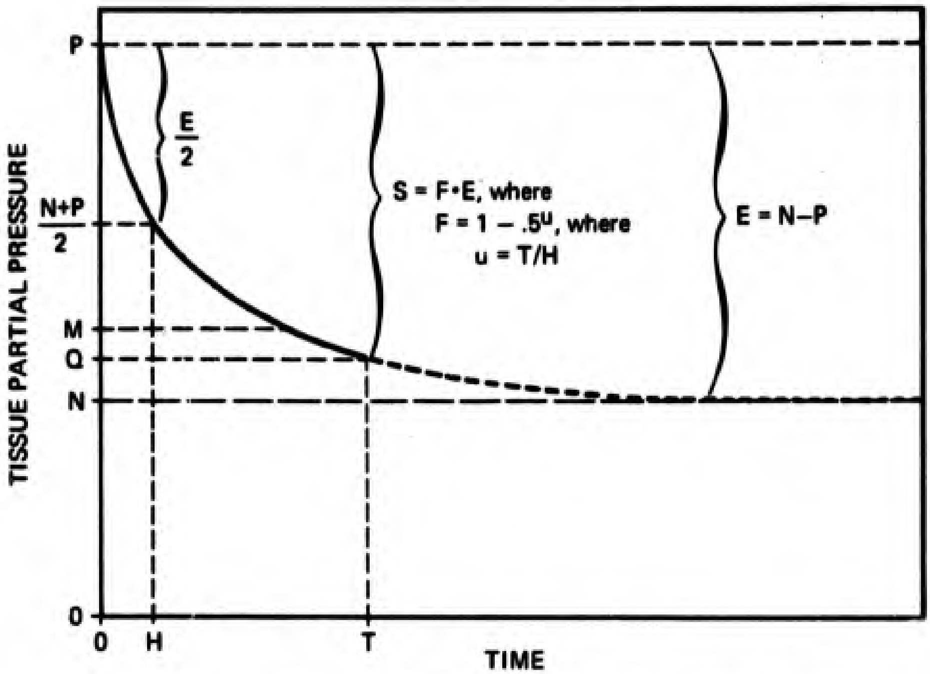

Figure 1: Inert gas partial pressure vs time in tissue of half-time H during decompression stop of length T minutes at ambient inert gas partial pressure N.

In figure 1, the value of partial pressure of inert gas is plotted (on the y-axis) against time (on the x-axis) for a tissue of half-time H during a typical decompression stop of length T minutes. The decrease in partial pressure is seen to be exponential with time from the tissue partial pressure at the beginning of the stop (P) to that at the end of the stop (Q). The curve is extended past the stop time (T) to its asymptote at the ambient partial pressure (N) to illustrate the time course for a very long stop.

The length of the stop (T) is the time necessary to reduce the partial pressure in the controlling tissue to less than or equal to a value (M) which has been found (empirically) to be safe for ascent to the next stop for this particular half-time tissue.

The actual change in tissue partial pressure (S) during this time is a certain fraction (F) of the inert gas gradient (E) between the ambient partial pressure at the stop (N) and the current tissue partial pressure (P). This fraction is determined from the standard exponential decay formula: $F = 1-e^{-kt}$, where $K = 0.693/H$. Since $e^{-0.693} = .5$, the formula can be rewritten: $F = 1-.5^{u}$, where the exponential time constant (u) is equal to the number of tissue half-times, or time units, spent at the stop (T/H).

III. CALCULATIONS

The three stages of calculation; exposure, ascent, and decompression are described in enough detail that someone familiar with the Workman paper should have no difficulty in performing the hand calculations. Copies of tables T, U, and M and a one-page short form (minus the explanations) are provided for convenience in repetitive calculations.

The exposure section uses the first column of the worksheet to calculate the inert gas partial pressure in each of the considered half-time tissues immediately before ascent. Step I.1.F requires you to look up the value of the time function (F) in table T for the specific bottom time (T) and each tissue half-time (H). Alternatively, you may calclate these values with the formula provided. This section may also be used to calculate desaturation during the surface interval before a repetitive dive. Substitute 0 ft. for depth of dive (D), surface interval for bottom time (T), residual (surfacing) tissue partial pressures (Q) for surface partial pressures (P), and then complete the calculations exactly as if it were a dive, being certain to observe the correct signs of the figures. The resulting Q's are then the surface partial pressures (P) for the following repetitive dive.

The ascent section introduces a formula for calculating the first decompression stop using the allowable surfacing tissue partial pressures (M10) and the changes in allowable tissue partial pressure per 10 ft. (ΔM), both from Workman's table M. (Workman actually presents a different table for each inert gas, N for nitrogen and H for helium, but here they are referred to collectively as table M.) The section then uses the second column of the worksheet to calculate the tissue partial pressures after ascent to the first stop. These are then tested to insure that the first stop is valid and appropriate corrections are indicated if it is not. Step II.2.F requires that you look up the value of the time function (F) in table U for the specific time unit (U) calclated. This calculation should be carried to three decimal places (rounded) and F values interpolated as necessary. A formula is provided for the alternative calculation.

The decompression section uses Workman's formula to calculate trial time functions (f) for each tissue in which P is greater than M. You must enter table T once again to find each trial time (t), but in the reverse manner. Find the trial time function (f) in the body of the table (always rounding to the next higher value in the table) and read the equivalent exposure time (t) at the margin. The largest of these times is then the stop time (T). An equation is provided for the formidable alternative of calculation. The tissue partial pressures at the end of the stop (Q) are then calculated and tested for validity. The second test points out when a stop may be skipped.

Note that for helium-oxygen dives where pure oxygen is to be used during decompression, the inert gas fraction (G) must be changed at the 50 ft. stop. As a rule, a value of G = .20 should be used in this case.

The one page short form "program" provided for your convenience in repetitive calculations is identical to the long form described above without the explanations or alternative formulae. If there is any confusion about the calculations or notation, refer back to the long version for explanation.

IV. DISCUSSION

Although this scheme tells you to calculate all the values for all tissues, you will learn from experience that trends can be found which will lessen the number of these values that you must work out. For example, to find the maximum of the trial first stops (and the trial stop times) all you have to do is bracket a value with two lesser ones to determine that it is a maximum, thereby saving half your calculations. This maximum will always be found only in the tissues where P is greater than M, and usually will be in the middle of this group. Also, the control of decompression tends to shift to tissues of greater half-time as you ascend, so you do not have to carry out calculations on tissues with half-times less than that of the controlling tissue.

Some of the tests included are really not necessary if you use the formulae and do not make any mathematical errors, but they are useful to keep you on the right track and help give you confidence in your output.

Several computer language programs have been written to perform these calculations at various facilities. Although they provide a great saving in time and energy, they are, for the most part, devised on the same bases as this scheme, produce the same results, suffer the same inadequacies, and should not be given any more credance than your own hand wrought tables. Your ability to derive these tables by hand is much more useful for the resulting basis for understanding and intelligent use of existing tables than it is for the mechanical production of schedules that is probably better handled by machines.

V. CONCLUSION

This report has explained the basic concepts of Workman's method for the calculation of decompression schedules and supplies a step-by-step program to lead the user through the calculations with a minimum of confusion. It should serve as a useful adjunct to Workman's original report as a teaching tool as well as a refresher and guide for use by experienced personnel.

REFERENCE

1. Workman, R. D. Calculation of decompression schedules for nitrogen-oxygen and helium-oxygen dives. U. S. Navy Experimental Diving Unit Research Report No. 6-65

APPENDIX A

I. EXPOSURE

G Enter decimal fraction of inert gas in the breathing mixture (eg. .79 in air)

H Enter half times of tissues to be considered (usually 5, 10, 20, 40, 80, and 120 minutes)

1. Calculate tissue partial pressures (Q) after exposure.

D Enter depth of dive in feet of seawater

A Enter absolute depth = D + 33

N Enter ambient inert gas partial pressure = G x A

T Enter bottom time in minutes.

For each tissue considered:

P Enter surface partial pressure = G x 33
(eg. .79 x 33 = 26 for air)
or residual tissue partial pressure (Q) if this is a repetitive dive.

F Enter time function from table T
or calculate: $F = 1 - .5^u$ where u = T/H

E Enter inert gas gradient = N - P

S Enter tissue partial pressure change = F x E

Q Enter new tissue partial pressure = P + S
(Exposure Q)

II. ASCENT

1. Calculate trial stop (TFS) for each tissue,

   $TFS = (Q - M_{10}) \times 10 / \Delta M$ where M_{10} is the M value for the 10 foot stop (allowable surfacing partial pressure) and ΔM is the change in M per 10 ft. depth increase; both from table M (N or H)

   Select the deepest TFS and round to the next deeper 10 foot increment for the first stop (FS).

2. Solve for ascent to first stop:

   D Enter average depth of ascent = (Bottom + FS) / 2

   A Enter average absolute depth = D + 33

   N Enter average ambient partial pressure = G x A

   T Enter ascent time in minutes = (Bottom - FS) / 60

   For each tissue considered:

   P Enter exposure partial pressure (Q from exposure)

   U Enter time unit = T/H

   F Enter time function from table T or calculate $F = 1 - .5^{u}$

   E Enter inert gas gradient = N - P

   S Enter tissue partial pressure change = F x E

   Q Enter new tissue partial pressure = P + S

   M Enter M values for first stop from table M (N or H)

3. Test resultant Q's against M's for validity of first stop:

   a. If all Q's are smaller than or equal to M's, this stop may be skipped. Subtract 10 ft. from FS and recalculate step II. 2. with new FS.

   b. If any Q is larger than the M values given for the stop 10 ft. deeper ($M + \Delta M$), add ten feet to FS and recalculate step II. 2. with this new FS.

   c. If the trial calculations pass these two tests, the first stop is valid. Proceed to the decompression.

III. DECOMPRESSION

1. Enter decompression stop parameters:

   D Enter depth of stop

   A Enter absolute depth of stop = D + 33

   N Enter ambient partial pressure = G X A

   For each tissue considered:

   P Enter previous tissue partial pressure (Q from previous stop or ascent)

   E Enter inert gas gradient = N - P

   M Enter M value for stop from table M (N or H)

2. Calculate trial time functions (f) for each tissue in which P is greater than M:

   $$f = (M - P) / E$$

   Find equivalent exposure times in table T or calculate: $t = -H\ (\ln (1 - f) / \ln 2)$, and round up to the next larger whole minute.

   The largest of these times (t) is the stop time (T).

3. Calculate tissue partial pressure at end of stop:

   T Enter stop time

   For each tissue considered:

   F Enter time function for table T or calculate: $F = 1 - .5^u$ where $u = T/H$

   S Enter tissue partial pressure change = F x E

   Q Enter new tissue partial pressure = P + S

4. Test resultant Q's:

   a. If <u>any</u> Q is larger than its M value, add 1 to T and recalculate step III. 3. with this new T.

   b. If <u>all</u> Q's are smaller than or equal to the M values for the <u>next</u> stop (M - ΔM), the next stop may be skipped.

5. Ascend ten feet to the next stop and repeat until at surface.

9

DECOMPRESSION TABLE CALCULATION

(Short Form)

G = Inert gas
H = Half times

Exposure:

D = Bottom
A = D + 33
N = G x A
T = Time
For each tissue:
- P = G x 33 (or surface Q)
- F = (table T)
- E = N - P
- S = F x E
- Q = P + S

Ascent:

For each tissue:
- TFS = $(Q - M_{10}) \times 10 / \Delta M$

FS = deepest TFS to next deeper 10 ft.
D = (Bottom + FS) / 2
A = D + 33
N = G x A
T = (Bottom - FS) / 60
For each tissue:
- P = Exposure Q
- U = T/H
- F = (table U)
- E = N - P
- S = F x E
- Q = P + S
- M = (table M)

Test each Q:
- If all Q's $\leq$ M's, FS = FS - 10
- If any Q $>$ $(M + \Delta M)$, FS = FS + 10

Decompression:

D = Stop
A = D + 33
N = G x A
For each tissue:
- P = Previous Q
- E = N - P
- M = (table M)
- f = (M - P) / E (where M>P)
- t = (table T)

T = largest t
For each tissue:
- F = (table T)
- S = F x E
- Q = P + S

Test each Q:
- If any Q $>$ M, T = T + 1
- If all Q's $\leq$ $(M - \Delta M)$, D = D - 20

Ascend to next stop:
10 D = D - 10

TABLE T

TIME FUNCTIONS (F)
(PERCENTAGE DECIMAL)

FOR DETERMINATION OF TISSUE PRESSURE IN 5, 10, 20, 40, 80, 120, 160, 200 AND 240 – MINUTE TISSUES DURING EXPOSURES UP TO 150 MINUTES.

EXPOSURE TIME MINUTES	TISSUE HALF TIME (Minutes)								
	5	10	20	40	80	120	160	200	240
1	.129	.066	.034	.017	.009	.004	.004	.002	.002
2	.242	.129	.066	.034	.017	.011	.009	.007	.004
3	.340	.187	.098	.050	.026	.017	.013	.011	.009
4	.425	.242	.129	.066	.034	.022	.017	.014	.011
5	.500	.293	.158	.083	.042	.028	.022	.018	.014
6	.564	.340	.187	.098	.050	.034	.025	.021	.017
7	.621	.384	.215	.114	.059	.039	.030	.024	.020
8	.669	.425	.242	.129	.067	.045	.034	.027	.022
9	.712	.463	.268	.144	.075	.050	.037	.031	.025
10	.750	.500	.293	.158	.083	.055	.042	.034	.028
11	.782	.533	.317	.173	.091	.061	.045	.038	.031
12	.811	.564	.340	.187	.099	.066	.050	.041	.034
13	.835	.593	.362	.201	.107	.072	.055	.044	.036
14	.857	.621	.384	.215	.114	.078	.059	.047	.039
15	.875	.646	.405	.229	.122	.083	.063	.051	.042
16	.892	.669	.425	.242	.129	.088	.067	.054	.045
17	.906	.692	.445	.254	.137	.093	.071	.057	.047
18	.918	.712	.463	.268	.144	.096	.074	.061	.050
19	.927	.732	.482	.280	.152	.103	.078	.064	.053
20	.937	.750	.500	.293	.158	.108	.084	.067	.055
21	.945	.766	.516	.304	.165	.114	.087	.070	.059
22	.953	.782	.533	.317	.173	.119	.090	.073	.061
23	.959	.797	.548	.328	.181	.124	.094	.077	.064
24	.963	.811	.564	.340	.187	.129	.099	.081	.066
25	.967	.824	.579	.351	.196	.134	.102	.083	.069
26	.972	.835	.593	.362	.201	.139	.107	.086	.072
27	.977	.847	.607	.373	.209	.143	.110	.089	.075
28	.980	.857	.621	.384	.215	.149	.114	.092	.078
29	.982	.866	.633	.395	.222	.154	.118	.096	.081
30	.985	.875	.646	.405	.229	.158	.122	.099	.083
31		.884	.657	.415	.236	.162	.125	.102	.085
32		.892	.669	.425	.242	.168	.129	.105	.088
33		.899	.681	.435	.249	.173	.132	.108	.090
34		.906	.692	.445	.255	.178	.137	.111	.093
35		.912	.702	.454	.262	.183	.141	.114	.095
36		.918	.712	.463	.268	.187	.144	.117	.098
37		.922	.722	.473	.275	.192	.148	.120	.101
38		.927	.732	.482	.280	.197	.151	.123	.103
39		.932	.741	.491	.287	.201	.154	.126	.106
40		.937	.750	.500	.293	.206	.159	.129	.108
41		.941	.758	.508	.299	.210	.162	.133	.111
42		.945	.766	.516	.304	.215	.166	.136	.114
43		.949	.774	.525	.311	.219	.169	.139	.116
44		.953	.782	.533	.317	.224	.173	.141	.119
45		.956	.790	.541	.323	.228	.177	.144	.121
46		.959	.797	.548	.328	.233	.180	.147	.124
47		.960	.804	.556	.335	.237	.184	.150	.126
48		.963	.811	.564	.340	.242	.188	.153	.129
49		.965	.817	.572	.346	.248	.192	.156	.131
50		.967	.824	.579	.351	.250	.195	.159	.134
51		.970	.830	.586	.357	.255	.198	.162	.137
52		.972	.835	.593	.362	.259	.201	.165	.139
53		.974	.841	.600	.369	.264	.205	.168	.141
54		.977	.847	.607	.373	.268	.208	.171	.143
55		.978	.852	.614	.379	.272	.211	.174	.146
56		.980	.857	.621	.384	.277	.215	.176	.149
57		.981	.862	.627	.390	.281	.218	.179	.151
58		.982	.866	.633	.395	.285	.222	.182	.154
59		.984	.871	.639	.400	.289	.226	.185	.156
60		.985	.874	.646	.405	.293	.229	.188	.159
61			.880	.652	.411	.297	.233	.191	.161
62			.884	.657	.415	.300	.235	.193	.164
63			.888	.664	.421	.304	.238	.196	.166
64			.892	.669	.425	.309	.242	.199	.169
65			.895	.675	.431	.313	.244	.201	.171
66			.899	.681	.435	.317	.248	.204	.173
67			.902	.686	.440	.321	.251	.207	.175
68			.906	.692	.445	.324	.255	.210	.178
69			.909	.697	.450	.328	.259	.213	.180
70			.912	.702	.455	.332	.262	.215	.183
71			.915	.707	.459	.336	.264	.218	.185
72			.918	.712	.464	.340	.268	.221	.187
73			.920	.717	.469	.342	.271	.224	.190
74			.922	.722	.473	.347	.274	.226	.192
75			.925	.727	.478	.352	.276	.229	.194

EXPOSURE TIME MINUTES	TISSUE HALF TIME (Minutes)						
	20	40	80	120	160	200	240
76	.927	.732	.482	.354	.280	.232	.197
77	.930	.736	.487	.359	.284	.235	.199
78	.932	.741	.491	.362	.287	.237	.201
79	.934	.745	.495	.368	.289	.240	.203
80	.937	.750	.500	.373	.293	.242	.206
81	.939	.754	.505	.374	.296	.245	.208
82	.941	.758	.508	.377	.299	.247	.210
83	.943	.763	.512	.381	.302	.250	.212
84	.945	.766	.516	.384	.305	.253	.215
85	.947	.770	.521	.387	.308	.256	.217
86	.949	.774	.524	.391	.310	.258	.219
87	.951	.778	.528	.395	.313	.261	.222
88	.953	.782	.533	.399	.317	.263	.224
89	.955	.786	.537	.402	.319	.266	.226
90	.956	.790	.541	.405	.323	.268	.228
91	.957	.794	.545	.408	.325	.271	.231
92	.959	.797	.550	.411	.328	.273	.233
93	.959	.797	.554	.415	.332	.275	.235
94	.960	.804	.557	.419	.334	.278	.237
95	.962	.807	.561	.423	.337	.281	.239
96	.963	.811	.565	.425	.340	.283	.242
97	.964	.814	.569	.428	.342	.285	.245
98	.965	.817	.573	.431	.346	.288	.248
99	.966	.820	.576	.435	.348	.291	.249
100	.967	.824	.580	.439	.352	.293	.250
101	.968	.826	.584	.442	.355	.295	.253
102	.970	.830	.587	.445	.357	.298	.255
103	.971	.832	.591	.448	.359	.301	.257
104	.972	.835	.594	.451	.363	.303	.259
105	.973	.838	.597	.455	.365	.305	.262
106	.974	.841	.601	.458	.368	.307	.264
107	.976	.844	.605	.461	.371	.310	.266
108	.977	.847	.608	.463	.374	.312	.268
109	.977	.849	.611	.466	.377	.314	.270
110	.978	.852	.615	.469	.379	.317	.272
111	.979	.854	.618	.472	.381	.320	.274
112	.980	.857	.622	.476	.384	.322	.277
113	.980	.859	.625	.479	.386	.324	.279
114	.981	.862	.628	.482	.390	.326	.281
115	.982	.864	.631	.484	.392	.329	.283
116	.982	.866	.634	.487	.395	.331	.285
117	.983	.868	.637	.491	.398	.333	.287
118	.984	.870	.640	.494	.400	.336	.289
119	.984	.873	.644	.497	.403	.338	.291
120	.985	.875	.647	.500	.405	.340	.293
121		.877	.650	.503	.407	.343	.295
122		.880	.653	.506	.411	.345	.297
123		.882	.656	.509	.413	.347	.299
124		.884	.659	.512	.416	.349	.300
125		.886	.662	.515	.418	.351	.302
126		.888	.665	.517	.421	.354	.304
127		.890	.668	.520	.424	.356	.306
128		.892	.670	.523	.426	.358	.309
129		.894	.673	.525	.428	.361	.311
130		.895	.676	.528	.431	.363	.313
131		.898	.679	.531	.433	.365	.315
132		.899	.682	.533	.436	.367	.317
133		.900	.685	.536	.438	.370	.319
134		.902	.687	.539	.440	.372	.321
135		.904	.690	.542	.443	.374	.323
136		.906	.693	.545	.445	.376	.324
137		.908	.695	.547	.447	.378	.326
138		.909	.698	.550	.450	.380	.328
139		.910	.701	.552	.452	.382	.330
140		.912	.703	.555	.455	.384	.332
141		.913	.705	.557	.457	.387	.334
142		.915	.708	.560	.459	.389	.336
143		.916	.711	.562	.462	.391	.338
144		.918	.713	.565	.464	.393	.340
145		.919	.715	.567	.466	.395	.342
146		.920	.718	.570	.469	.397	.344
147		.920	.720	.572	.471	.399	.346
148		.922	.723	.575	.474	.401	.347
149		.924	.725	.577	.476	.403	.349
150		.925	.728	.580	.478	.405	.352

11

TABLE U

Time Unit (U) [Second Decimal Place]

Rows: Time Unit (U) [Integer and First Decimal Place]; entries: Time Function (F) [Three Decimal Places]

	0	1	2	3	4	5	6	7	8	9
0.0	----	.007	.014	.021	.027	.034	.041	.047	.054	.061
0.1	.067	.073	.081	.086	.092	.099	.105	.111	.117	.123
0.2	.129	.136	.141	.147	.153	.159	.165	.171	.176	.182
0.3	.188	.193	.199	.204	.210	.215	.221	.226	.232	.237
0.4	.242	.247	.253	.258	.263	.268	.273	.278	.283	.288
0.5	.293	.298	.303	.307	.312	.317	.322	.326	.331	.336
0.6	.340	.345	.349	.354	.358	.363	.367	.372	.376	.380
0.7	.384	.389	.393	.397	.401	.405	.410	.414	.418	.422
0.8	.426	.430	.434	.438	.441	.445	.449	.453	.457	.460
0.9	.464	.468	.472	.475	.479	.482	.486	.490	.493	.496
1.0	.500	.503	.507	.510	.514	.517	.520	.524	.527	.530
1.1	.533	.537	.540	.543	.546	.549	.553	.556	.559	.562
1.2	.565	.568	.571	.574	.577	.580	.583	.585	.588	.591
1.3	.594	.597	.600	.602	.605	.608	.610	.613	.616	.618
1.4	.621	.624	.626	.629	.632	.634	.637	.639	.642	.644
1.5	.646	.649	.651	.654	.656	.659	.661	.663	.666	.668
1.6	.670	.672	.675	.677	.679	.681	.684	.686	.688	.690
1.7	.692	.694	.697	.699	.701	.703	.705	.707	.709	.711
1.8	.713	.715	.717	.719	.721	.723	.725	.726	.728	.730
1.9	.732	.734	.736	.738	.739	.741	.743	.745	.747	.748
2.0	.750	.752	.754	.755	.757	.759	.760	.762	.764	.765
2.1	.767	.768	.770	.772	.773	.775	.776	.778	.779	.781
2.2	.782	.784	.785	.787	.788	.790	.791	.793	.794	.796
2.3	.797	.798	.800	.801	.803	.804	.805	.807	.808	.809
2.4	.811	.812	.813	.815	.816	.817	.818	.820	.821	.822
2.5	.823	.824	.826	.827	.828	.829	.830	.832	.833	.834
2.6	.835	.836	.837	.839	.840	.841	.842	.843	.844	.845
2.7	.846	.847	.848	.849	.850	.851	.852	.853	.854	.855
2.8	.856	.857	.858	.859	.860	.861	.862	.863	.864	.865
2.9	.866	.867	.868	.869	.870	.871	.872	.872	.873	.874
3.0	.875	.876	.877	.878	.878	.879	.880	.881	.882	.883
3.1	.883	.884	.885	.886	.887	.887	.888	.889	.890	.890
3.2	.891	.892	.893	.893	.894	.895	.896	.896	.897	.898
3.3	.899	.899	.900	.901	.901	.902	.903	.903	.904	.905
3.4	.905	.906	.907	.907	.908	.909	.909	.910	.910	.911
3.5	.912	.912	.913	.913	.914	.915	.915	.916	.916	.917
3.6	.918	.918	.919	.919	.920	.920	.921	.921	.922	.923
3.7	.923	.924	.924	.925	.925	.926	.926	.927	.927	.928
3.8	.928	.929	.929	.930	.930	.931	.931	.932	.932	.933
3.9	.933	.934	.934	.934	.935	.935	.936	.936	.937	.937
4.0	.938	.938	.938	.939	.939	.940	.940	.941	.941	.941
4.1	.942	.942	.943	.943	.943	.944	.944	.944	.945	.945
4.2	.946	.946	.946	.947	.947	.947	.948	.948	.949	.949
4.3	.949	.950	.950	.950	.951	.951	.951	.952	.952	.952
4.4	.953	.953	.953	.954	.954	.954	.955	.955	.955	.956
4.5	.956	.956	.957	.957	.957	.957	.958	.958	.958	.959
4.6	.959	.959	.959	.960	.960	.960	.960	.961	.961	.961
4.7	.962	.962	.962	.962	.963	.963	.963	.963	.964	.964
4.8	.964	.964	.965	.965	.965	.965	.966	.966	.966	.966
4.9	.967	.967	.967	.967	.967	.968	.968	.968	.968	.969

TABLE M (NITROGEN)

Table of Maximum Allowable Tissue Tensions in Feet of Sea Water (M) of Nitrogen for Various Half-time Tissues for ascent to next stop.

Depth of decompression stop

H (min)	10	20	30	40	50	60	70	80	90	100
5	104	122	140	158	176	194	212	230	248	266
10	88	104	120	136	152	168	184	200	216	232
20	72	87	102	117	132	147	162	177	192	207
40	56	70	84	98	112	126	140	154	168	182
80	54	67	80	93	106	119	132	145	158	171
120	52	64	76	88	100	112	124	136	148	160
160	51	63	74	86	97	109	120	132	143	155
200	51	62	73	84	95	106	117	128	139	150
240	50	61	72	83	94	105	116	127	138	149

ΔM/Δ10 feet depth

H (min)	5	10	20	40	80	120	160	200	240
ΔM (ft)	18	16	15	14	13	12	11.5	11	11

TABLE M (HELIUM)

Table of Maximum Allowable Tissue Tension in Feet of Sea Water (M) of Helium for Various Half-time Tissues for ascent to next stop.

Depth of decompression stop

H (min)	10	20	30	40	50	60	70	80	90	100
5	86	101	116	131	146	161	176	191	206	221
10	74	88	102	116	130	144	158	172	186	200
20	66	79	92	105	118	131	144	157	170	183
40	60	72	84	96	108	120	132	144	156	168
80	56	68	80	92	104	116	128	140	152	164
120	54	66	78	90	102	114	126	138	150	162
160	54	65	76	87	98	109	120	131	142	153
200	53	63	73	83	93	103	113	123	133	143
240	53	63	73	83	93	103	113	123	133	143

$\Delta M/\Delta 10$ feet depth

H (min)	5	10	20	40	80	120	160	200	240
ΔM (ft)	15	14	13	12	12	12	11	10	10

Worksheet

G	D												
	A												
	N												
	T												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												

H	U												
	F												
	E												
	P												
	S												
	Q												
	M												