TECHNIFACTS

High Altitude Decompression BY E. R. CROSS

Three years ago, SDM Technifacts discussed high altitude diving and the importance of using specially modified high altitude decompression tables following such dives. Based on articles in Skin Diver since then, and from questions asked Technifacts and at a recent NAUI instructors course, it seems that some of the information should be repeated and new data presented.

There are two modifications to make to regular air decompression tables if they are to be used for high altitude decompression. The diver must compute, or refer to a table, to obtain the theoretical depth of the dive for each altitude and the diver must arrive at the theoretical depths of decompression stops at the altitude of the dive. Both theoretical diving depth and decompression stop depths vary with different altitudes.

Table "A" gives theoretical diving depths at altitudes to 10,000 feet for actual diving depths to 250 feet. To use this table, enter the left column (actual diving depth) with the actual, or next greater, depth of the dive. Across from this depth, in the columns at the right, find the altitude of the body of water in which the dive is being made. Use the next higher altitude if altitude falls between those listed. The figure given in the selected altitude column for the actual depth is the theoretical depth of the dive at that altitude.

As an example, assume a dive is to be made in a lake at an altitude of 4,000 feet. Actual depth of the dive is to be 90 feet. Across from 90 feet in column 1 for an altitude of 4,000 feet will be found the theoretical depth of 104 feet. The rule of using the next greater depth also applies in high altitude diving, so the theoretical depth used for this dive would be 110 feet.

Further assume the first dive is to be for 35 minutes. At what depths and for what times are the decompression stops? Enter the standard air decompression tables for a depth of 110 feet for a dive of 35 minutes. Using the next greater time (40 minutes) it will be found that the decompression schedule calls for decompression stops at 20 feet for 2 minutes and at 10 feet for 21 minutes. But actual depths of the decompression stops must also be changed to theoretical decompression stop depths. In Table "B" it will be found that at an altitude of 4,000 feet, the 20 foot stop must be taken at a depth of 17 feet and the 10 foot stop at a depth of 9 feet. Therefore, theoretical decompression stops that are to be followed will be 2 minutes at 17 feet and 21 minutes at a depth of 9 feet.

Does this also work with the repetitive dive tables? Yes, they must also be modified to obtain theoretical depth values. First take the misnamed "no decompression" tables.

Again using the 4,000 foot altitude example, what is the depth time limit at various depths? An inspection of Table "A" will show that a dive to an actual depth of 30 feet at 4,000 feet is equivalent to a dive to 35 feet at sea level. Now enter the no decompression table for that depth and it will be found the no decompression limit for that depth (35 feet) is 310 minutes. This means that, at 4,000 feet above sea level, a dive to an actual depth of 30 feet must be limited to 310 minutes instead of unlimited time as at sea level (if decompression stops are to be avoided).

In the previous example of a dive to an actual depth of 90 feet at an altitude of 4,000 feet, the theoretical depth was found to be 110 feet. No decompression limit for this dive would be 20 minutes. Note that the designator at the end of the dive would be for the theoretical depth for altitude and not for actual diving depth.

In the table for obtaining repetitive group designator at the end of surface interval, no application of altitude diving tables is required since depth is not a function of this table. However, theoretical depth is a factor in the repetitive dive, or dives, that may follow. Taking the original example of a 90 foot dive for 35 minutes at an altitude of 4,000 feet, assume a repetitive dive to an actual depth of 60 feet after a surface interval of 2 hours 19 minutes. What will be the no decompression time limit?

It has already been determined that the theoretical diving depth for a 90 foot dive at 4,000 feet is 110 feet. For a 35 minute (40 minutes must be used) dive at 110 feet the repetitive group

TABLE A

THEORETICAL DEPTH AT ALTITUDE FOR GIVEN ACTUAL DIVING DEPTH (IN FRESH WATER

Actual Depth	Theoretical Depth at Various Altitudes (in feet)									
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
0	0	0	0	0	0	0	0	0	0	0
10	10	11	11	12	12	12	13	13	14	15
20	21	21	22	23	24	25	26	27	28	29
30	31	32	33	35	36	37	39	40	42	44
40	41	43	45	46	48	50	52	54	56	58
50	52	54	56	58	60	62	65	67	70	73
60	62	64	67	69	72	75	78	81	84	87
70	72	75	78	81	84	87	91	94	98	102
80	83	86	89	92	96	100	103	108	112	116
90	93	97	100	104	108	112	116	121	126	131
100	103	107	111	116	120	124	129	134	140	145
110	114	118	122	127	132	137	142	148	153	160
120	124	129	134	139	144	149	155	161	167	174
130	135	140	145	150	156	162	168	175	181	189
140	145	150	156	162	168	174	181	188	195	203
150	155	161	167	173	180	187	194	202	209	218
160	166	172	178	185	192	199	207	215	223	232
170	176	182	189	195	204	212	220	228	237	247
180	186	193	200	208	216	224	233	242	251	261
190	197	204	212	220	228	237	246	255	265	276
200	207	215	223	231	240	249	259	269	279	290
210	217	225	234	243	252	261	272	282	293	305
220	228	236	245	254	264	274	284	296	307	319
230	238	247	256	266	276	286	297	309	321	334
240	248	258	267	277	288	299	310	323	335	348
250	259	268	278	289	300	311	323	336	349	363

TABLE B

THEORETICAL DEPTH OF DECOMPRESSION STOP AT ALTITUDE

Prescribed Depth	Theoretical Depth of Decompression Stop (in feet)									
	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
0	0	0	0	0	0	0	0	0	0	0
10	10	9	9	9	8	8	8	7	7	7
20	19	19	18	17	17	16	15	15	14	14
30	29	28	27	26	25	24	23	22	22	21
40	39	37	36	35	33	32	31	30	29	28

Must slow down ascent ~~rate~~ by 2'/min for every 1000' altitude

designator is "L". After a 2 hour 19 minute surface interval, an "L" diver becomes a "G" diver. The repetitive dive was to an actual depth of 60 feet. In Table "A" for 4,000 feet it will be found that an actual dive to 60 feet is equivalent to a depth of 60 feet. Using 70 feet, again refer to the repetitive dive group designator and it will be found that as a "G" diver going to 70 feet, an equivalent exposure of 37 minutes exists. For a dive to 70 feet the maximum no decompression time limit is found to be 50 minutes. The diver already has an equivalent exposure of 37 minutes for the new depth which leaves an actual diving time of only 13 minutes unless decompression stops can be programmed.

Now let's assume that a diver makes his first dive to a depth of 90 feet (theoretical depth 110 feet) at an altitude of 4,000 feet. After a surface interval of 2 hours 19 minutes, during which time the diver drove to sea level, he makes a repetitive dive to a depth of 60 feet in the ocean. What happens to the tables?

For the first dive at altitude, use the theoretical depth and theoretical decompression stop depths as in the first example. After the surface interval and drive to sea level pressure, simply assume the original dive was made to actual depth and actual decompression stop depths at sea level. In other words, once sea level pressure is reached the diver may assume the dive was made to a depth of 90 feet for 35 minutes and that prescribed decompression was taken for such a dive (7 minutes at ten feet). Following this the diver is a "J" diver (at sea level) and after 2 hours 19 minutes surface interval he is an "F" diver. Now entering repetitive dive tables, it will be found the diver has an equivalent exposure (for a 60 foot dive) of 36 minutes. Since the no-decompression limit for a 60 foot dive is 60 minutes, the diver finds he now has 24 minutes diving time before requiring decompression stops.

Now reverse the procedure. Make the first dive at sea level and then go to altitude in the same 2 hours 19 minutes, and make the 60 foot dive at altitude of 4,000 feet. What happens?

On the completion of the 90 foot dive for 35 minutes at sea level, if the diver has immediately gone to an altitude of 4,000 feet, the sea level dive must be treated as though it were made at an altitude of 4,000 feet. The repetitive dive would also be treated as in the previous example for a repetitive dive at 4,000 feet.

Should treatment tables for decompression sickness also be modified for use at high altitudes? It is even more important to modify the treatment tables because of the greater tissue saturation of the diver who has been bent and because time at depths involved in treatment are longer than most dives. However, the stops at various depths as given in the treatment tables are treated as decompression stops, not as diving depths. Therefore each treatment stop is slightly less than actual prescribed stops, the amount depending on the altitude.

Stops are given in Table "B" for decompression (or treatment) for 0 to 40 feet at various altitudes from 1,000 to 10,000 feet. Stops deeper than 40 feet may be computed as follows:

$\frac{P^2}{P^1} \times D^1 = D^2$, where P^1 = barometric pressure at sea level (in mm Hg); P^2 = barometric pressure at altitude; D^1 = depth of decompression (treatment) stop from standard tables; and D^2 = theoretical depth of the stop. Note: SDM Technifacts for December, 1967, presented a table of barometric pressures (in mm Hg) at altitudes.

In the event that treatment for bends is required and the patient is rushed to a chamber at sea level pressure, no change in the treatment table is required, simply because the dive and the resultant bends occurred at altitude.

Can altitude decompression tables be used for diving then flying? There is no reason why they couldn't be. Plan a day's diving, and more importantly, the day's decompression schedule, as though diving at an altitude equal to the highest altitude the plane will reach, if unpressurized, or at the pressurized altitude in the event of an air liner that is pressurized. Check with the airline to see what altitude their plane cabins will be pressurized for on your flight.

The conversion tables for high altitude decompression, first published in SDM for December, 1967, have been used quite extensively and have been found to be as safe as the air tables which they modify. In the December, 1967 Technifacts there was also a discussion of formulas for determining the various theoretical factors. Interested readers may refer to that issue for the formula. For field use, Tables "A" and "B" are all that are required for converting actual diving depths at altitudes to theoretical diving depths as well as for converting actual decompression stop depths to theoretical depths. ➤

DECOMPRESSION CONSIDERATIONS FOR DIVING AT ALTITUDE IN FRESH WATER

The U.S. Navy Repetitive Air Decompression Tables are based on the diver's surfacing to barometric pressure at sea level from depth in sea water. In order to decompress adequately and avoid "bends" following dives at altitude and/or in fresh water, a different set of tables would be needed for each situation. A more practical approach is the use of equivalent depth tables which can be used with the existing Navy Tables. Below is such a table, theoretically valid but as yet untested, computed for Lake Tahoe.

EQUIVALENT DEPTH TABLE FOR LAKE TAHOE

Depth in Lake Tahoe	Equivalent Sea Depth
8 ft.	10 ft.
12	15
16	20
20	25
24	30
28	35
32	40
40	50
48	60
57	70
65	80
73	90
81	100
89	110
97	120
105	130
114	140
122	150
130	160
138	170
146	180
154	190

Example: a 60 ft. dive for 30 min. followed 2 hrs. later by a 50 ft. dive for 40 min. The exact or next greater equivalent depth for 60 ft. is 80 ft. which gives repetitive group "G" for 30 min. bottom time. After 2 hrs. this becomes group "D". The "residual nitrogen time" for the 50 ft. dive found under the equivalent depth of 70 ft. is 20 min. This gives a total of 60 min. bottom time at the equivalent depth of 70 ft. and requires an 8 minute stop at a depth equivalent to 10 ft. in the sea -- 8 ft. giving group "K" at the end of the dive.

Note: Ascent rate should be 48 ft. per min.

decrease ascent rate 2'/min for 1000' altitude

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