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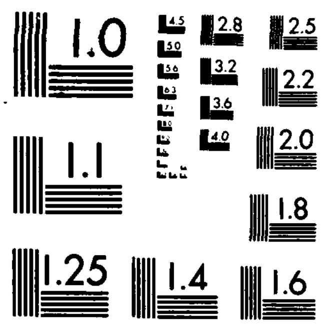

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NAVY EXPERIMENTAL DIVING UNIT
REPORT NO. 8-85

AIR-N_2O_2 DECOMPRESSION COMPUTER ALGORITHM DEVELOPMENT

By:

Edward D. Thalmann, CAPT, MC, USN

August 1986

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NAVY EXPERIMENTAL DIVING UNIT

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COMPUTER ALGORITHM	DECOMPRESSION TABLES	REPETITIVE DIVING
COMPUTER MODEL	MATHEMATICAL MODEL	NEDU TP NO. 84/30
CONSTANT OXYGEN PARTIAL PRESSURE	MK 15 UBA	
DECOMPRESSION MODEL	MK 16 UBA	

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A computer algorithm which can compute decompression schedules for air or a N_2O_2 breathing mix of any PO_2 was developed and tested. Testing consisted of 837 man dives on some 38 different profiles. There were 19 air bounce dive profiles from depths of 50-190 FSW, 5 being no-decompression dives. Four bounce profiles at 100 and 150 FSW were tested breathing a constant 0.7 ATA PO_2 in N_2 throughout. Three profiles at 60, 100 and 150 FSW where air was breathed on the bottom and a constant 0.7 ATA PO_2 in N_2 mix was breathed during decompression were tested. There were 10 air repetitive dive profiles at depths of 80, 100, 120 and 150 FSW, 7 of which were for no-decompression dives. Two long duration multiple level (20-100 FSW) dives where gas switches were made between air and a constant 0.7 ATA PO_2 breathing mix were also done. All dives were cold, wet, working dives and all decompression schedules were computed in real time using a HP-1000 computer which constantly monitored chamber depth. A total of 49 cases of decompression sickness (DCS) resulted all of which were successfully treated. The following no-decompression depth/time limits were tested without DCS: 60/66, 100/30, 120/24, 150/14, 190/10. Testing showed that repetitive dive no-decompression limits could probably be extended but that total decompression times for both bounce and repetitive decompression dive had to be extended considerably compared to U.S. Navy Standard Air Tables. Decompression time for constant 0.7 ATA PO_2 in N_2 dives could be shortened compared to current tables. The final decompression model uses total gas tension in determining decompression stops and computes a venous oxygen tension from an arterial value based on the hemoglobin disassociation curve and an assumed tissue metabolic rate. Gas uptake is assumed exponential while offgassing is assumed linear while a gas phase is present and exponential thereafter. The final decompression model can compute decompression schedules for a dive of any complexity and any oxygen level with nitrogen as the inert gas. The PO_2 may be changed at any time during the dive. The model is suitable for programming into a small portable microprocessor based decompression computer for real time computations.

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ABSTRACT

A computer algorithm which can compute decompression schedules for air or a N_2O_2 breathing mix of any PO_2 was developed and tested. Testing consisted of 837 man dives on some 38 different profiles. There were 19 air bounce dive profiles from depths of 50-190 FSW, 5 being no-decompression dives. Four bounce profiles at 100 and 150 FSW were tested breathing a constant 0.7 ATA PO_2 in N_2 throughout. Three profiles at 60, 100 and 150 FSW where air was breathed on the bottom and a constant 0.7 ATA PO_2 in N_2 mix was breathed during decompression were tested. There were 10 air repetitive dive profiles at depths of 80, 100, 120 and 150 FSW, 7 of which were for no-decompression dives. Two long duration multiple level (20-100 FSW) dives where gas switches were made between air and a constant 0.7 ATA PO_2 breathing mix were also done. All dives were cold, wet, working dives and all decompression schedules were computed in real time using a HP-1000 computer which constantly monitored chamber depth. A total of 49 cases of decompression sickness (DCS) resulted all of which were successfully treated. The following no-decompression depth/time limits were tested without DCS: 60/66, 100/30, 120/24, 150/14, 190/10. Testing showed that repetitive dive no-decompression limits could probably be extended but that total decompression times for both bounce and repetitive decompression dive had to be extended considerably compared to U.S. Navy Standard Air Tables. Decompression time for constant 0.7 ATA PO_2 in N_2 dives could be shortened compared to current tables. The final decompression model uses total gas tension in determining decompression stops and computes a venous oxygen tension from an arterial value based on the hemoglobin disassociation curve and an assumed tissue metabolic rate. Gas uptake is assumed exponential while offgassing is assumed linear while a gas phase is present and exponential thereafter. The final decompression model can compute decompression schedules for a dive of any complexity and any oxygen level with nitrogen as the inert gas. The PO_2 may be changed at any time during the dive. The model is suitable for programming into a small portable microprocessor based decompression computer for real time computations.

KEY WORDS:

Air Decompression Tables
Computer Algorithm
Computer Model
Constant Oxygen Partial Pressure
Decompression Model
Decompression Sickness
Decompression Tables
Mathematical Model
MK 15 UBA
MK 16 UBA
Nitrogen-Oxygen Decompression Tables
Repetitive Diving
NEDU Test Plan Number 84/30

GLOSSARY

Actual Dive Profile - A table or graph showing the actual depth/time coordinates for an entire dive.

Algorithm - A sequence of logical steps used to obtain a mathematical result.

Ascent Criteria - A set of constraints on a decompression model which defines how ascent may be accomplished without causing decompression sickness.

Bottom Time - The elapsed time from leaving the surface until beginning ascent to the first decompression stop (or the surface if a no-decompression dive).

Bounce Dive - A dive where descent is made to some depth for a specified time and then decompression is done to the surface without stopping at any depth not required by the decompression schedule.

Controlling Tissue - The theoretical tissue which will require the longest time to offgas from its current tension to its maximum tension at a given stop depth.

Computer Program - A series of instructions directing a computer how to process information to obtain the desired output. A computer program may contain one or more algorithms which perform intermediate calculations. As an example, a computer program for an Underwater Decompression Computer (UDC) may contain algorithms describing gas uptake and elimination, rules for finding the first stop and warning the diver when he is outside of the tested limits.

Decompression Model - A series of algorithms which describe how gas is taken up and given off by the body during a dive and what conditions must be met in order to avoid decompression sickness.

Decompression Obligation - The total amount of decompression stop time accrued at any time in a dive profile if ascent were begun at that instant at a specified rate.

Decompression Profile - A table or graph showing the depth-time coordinates for an entire dive including all desired stops and all obligatory decompression stops.

Decompression Schedule - A listing showing required decompression stop depths and stop times for a particular bottom depth/time dive at specified ascent and descent rates.

Decompression Table - A structured set of decompression schedules usually organized in order of increasing bottom depths and bottom times.

Dive Profile - A table or graph of depth/time coordinates for an entire dive showing all desired stops without regard to decompression obligation.

EL-MK 15/16 Decompression Model (DCM) - The particular series of algorithms which describe the assumptions used in computing decompression profiles or tables for use with the closed circuit 0.7 ATA constant PO_2 underwater breathing apparatus as described in reference 1.

EL-MK 15/16 DCM-I - A modification to the EL-MK 15/16 DCM which adjusted the MPTT's to take variations in tissue oxygen tension into account. A different set of MPTT's are required for each inspired PO_2 or oxygen fraction.

EL-MK 15/16 DCM-II - A modification of the EL-MK 15/16 DCM which contains all necessary equations for computing tissue oxygen tensions from inspired values. This allows a single set of MPTT's to be used for any inspired oxygen tension or fraction.

FSW - Abbreviation for Feet of Seawater.
33 FSW = 1 ATA = 760 mmHg.

MPTT - Maximum Permissible Tissue Tension. The maximum tension which can be present in any tissue at a given depth such that decompression sickness will not occur.

No-Decompression Time - (No-D Time) - The maximum time which can be spent at a given depth (including descent time at a specified rate) such that ascent can be made directly to the surface at a prescribed rate.

Repetitive Dive - A bounce dive occurring after a previous bounce dive with an intervening interval spent at the surface breathing air.

Residual Nitrogen Time - The time added to the bottom time of a repetitive dive to take into account the increased tissue tensions at the beginning of the dive resulting from a previous dive.

SAD - Safe Ascent Depth. The shallowest depth which could be ascended to at any time in a dive profile without violating the ascent criteria. The SAD is used in real time decompression profile execution and is computed and displayed by the EL-MK 15/16 RTA.

SDR - Saturation-Desaturation Ratio. The ratio of the theoretical tissue halftime used to compute gas uptake to the halftime used to compute gas elimination.

Set Point - The PO2 in a closed circuit UBA at which oxygen is added to the breathing loop.

TDT - Total Decompression Time. The total time required from leaving the bottom until reaching the surface after taking all required decompression stops.

Tension - The partial pressure of a gas in a gas mixture.

Theoretical Halftime Tissue - A conceptual area of body tissue whose gas uptake can be described by an exponential term with a time constant K or halftime equal to ln(2)/K.

Underwater Decompression Computer (UDC) - A small microprocessor device carried by a diver which continuously samples depth and updates his decompression obligation.

Air-N_2O_2 Decompression
Computer Algorithm Development

By: Edward D. Thalmann, CAPT, MC, USN

INTRODUCTION: Testing of a computer algorithm for diving while breathing a constant 0.7 ATA PO_2 in N_2 had been completed at the Navy Experimental Diving Unit in August 1980. This algorithm was used to generate a set of decompression tables (1) and is also being programmed into a small, portable wrist-worn Underwater Decompression Computer (UDC) for use with constant PO_2 closed-circuit Underwater Breathing Apparatus (UBA). Interest in the Special Warfare Community in being able to switch between a constant PO_2 breathing gas and air, coupled with interest in seeing if the constant PO_2 algorithm could be extended to air, lead to the study reported here.

The overall plan at the inception of the present study was to develop a computer algorithm which would allow any desired changes in inspired oxygen tension during a dive with nitrogen as the inert gas. An initial feasibility phase looked at what modifications would have to be made to the previously tested Exponential Linear MK 15/16 Decompression Model (EL-MK 15/16 DCM) in order to allow switches in oxygen tensions. Next, a dive series was conducted which was divided into 3 phases. Phases 1A and 1B examined air bounce dives using both U.S. Navy Standard Air Tables (6) as well as decompression profiles generated using a modified EL-MK 15/16 DCM. Phase 2 looked at additional air bounce dives using only computer generated decompression profiles, repetitive air dives, dives in which the breathing gas was switched between air and a constant 0.7 ATA PO_2 in N_2 and dives breathing a constant 0.7 ATA PO_2 in N_2 throughout. Phase 3 looked at repetitive air dives and long multiple level dives where switches were made between air and constant 0.7 ATA PO_2 in N_2. All phases of the dive series were completed between August and December of 1984. A total of 837 man dives were done which resulted in 49 cases of decompression sickness.

METHODS:

General

All 126 divers who participated in this study were active duty Navy or Army divers, or military trained civilians. Divers from the U.S., Canadian and British military participated. The physical characteristics of all divers are given in Appendix A. One of the divers (#110) was a female. There were 4 separate dive series (Phases 1A, 1B, 2 and 3) and some subjects participated in more than one series. Divers were all actively exercising up to the time of their participation in the study and were all in good physical condition. All divers were given thorough diving physical examinations before each dive series began and were examined immediately before and after each dive by a U.S. Navy Diving Medical Officer.

Breathing gas for the dive was either compressed air (FO_2=20.95%) supplied through open circuit SCUBA regulators or a constant 0.7 ATA PO_2 in N_2 supplied by a MK 15 closed circuit UBA. In dives where switches were made between air and the constant 0.7 ATA O_2 mix, the divers wore the MK 15 on their bac' and breathed air from SCUBA regulators attached to a manifold on an underwater habitat.

All divers were thoroughly trained in the use of the MK 15 closed-circuit constant PO_2 UBA which had the PO_2 setpoint adjusted to 0.7 ATA. A complete description of the MK 15 hardware and operating characteristics is given in references (2) and (3). With a PO_2 setpoint of 0.7 ATA, the MK 15 will automatically add oxygen when the PO_2 falls to 0.7 ATA. Normally, the PO_2 will have a mean level between 0.7 ATA and 0.8 ATA, but could be as low as 0.6 ATA without the UBA indicating a malfunction. This PO_2 range is maintained irrespective of depth. There is an alarm light that will warn a diver if his PO_2 falls to 0.6 ATA. If this happened during dives in this study, the diver was instructed to manually add oxygen and to change to another UBA if PO_2 could not be maintained automatically in the 0.6-0.8 ATA range. As long as no alarm lights indicated a low PO_2, divers were instructed to let the UBA control automatically and no attempt was made to control the PO_2 at exactly 0.7 ATA. The diluent used for all MK 15 dives in this series was 100% nitrogen. Operationally air will be used as a diluent which would result initially in higher oxygen partial pressures immediately after compression as diluent gas is added to the breathing loop to make up volume during descent. By using 100% nitrogen the oxygen partial pressure during the first portion of time at depth will be lower than it will be when operational dives take place. Since a lower PO_2 is presumed to increase decompression obligation, schedules were tested under conditions of maximum decompression stress with respect to oxygen partial pressure.

All dives were conducted in the 15 foot diameter by 46 foot long wet chamber of the Ocean Simulation Facility (OSF) at the Navy Experimental Diving Unit (NEDU) in Panama City, Florida. Divers were generally divided into 10 man teams. While at depth the 10 divers performed intermittent exercise at 75 watts on an electrically braked bicycle ergometer pedalling at 55-60 RPM. Since only 5 bicycle ergometers were available, only half the divers were actually exercising at a given time. Exercise periods lasted 6 minutes after which time the 5 non-exercising divers mounted the ergometers and began exercising. This alternating 6 minute work, 6 minute rest cycle continued until 1 minute prior to decompression at which time all exercise stopped[1]. Previous studies showed that the mean oxygen consumption for divers in wetsuits pedalling 55-60 RPM doing this alternating work/rest cycle was approximately 1.00-1.2 ℓ/min with a 1.6-1.8 ℓ/min oxygen consumption during exercise and a 0.4-0.5 ℓ/min oxygen consumption at rest (1)[2]. All divers remained at rest for the entire decompression.

All dives were done in cold water with divers wearing full ¼" neoprene wetsuits consisting of "Farmer John" trousers, jacket, hood, gloves and boots. Water temperature was set (± 2°F) according to the total dive time as follows: 250 min or greater, 65°F; 249-190 min 60°F; 179-80 min 55°F; 79 min or less 50°F. For repetitive dives, the water temperature was set according to the shortest in-water segment of dive, surface intervals were not considered in setting water temperatures. Most divers were visibly chilled and shivering when exiting from dives, indicating a significant thermal stress during the dive.

Inspired CO_2 was less than 1 mmHg during air dives as confirmed by analysis of the air banks. No CO_2 measurements were made when the divers were breathing from the MK 15 but previous experience with this UBA showed that inspired CO_2 would not rise above 2 mmHg in a normally functioning UBA during the maximum times it would be in use during these dives (1).

Descent rates were 30-60 FSW/min depending on diver's ability to clear their ears. Occasionally there were holds on the way down followed by intermittent ascents because of eustachian tube blockage in some divers. Since the decompression schedules were all computed in real time all these holds were taken into account in determining actual decompression obligation. Ascent rates were 60 FSW/min to 20 FSW, 40 FSW/min from 20 to 10 FSW, and 30 FSW/min from 10 FSW to the surface, these being the maximum OSF wet chamber travel rates over these depth ranges.

The wet chamber was pressurized with air for all dives. Occasionally, a diver would have to come off his UBA at depth. A dry underwater refuge was in the wetpot and always contained an air atmosphere. During air dives, breathing refuge atmosphere had no effect on the diver's decompression status. If divers were breathing from the MK 15 UBA, then breathing refuge atmosphere would cause his inspired PO_2 to be different from his fellow divers during that time. In these circumstances, if a diver breathed refuge atmosphere for more than a few minutes he was eliminated as a test subject from that particular dive. Chamber occupants (tenders or divers withdrawn from the wetpot) usually breathed an N_2O_2 mix which was higher than that being breathed by the divers. This mix was either 40.0% O_2 down to 150 FSW and 32.5% for deeper dives. During decompression, the same gas breathed at depth was used until a depth of 30 FSW was reached at which point chamber occupants were switched to 100% O_2 for the remainder of decompression. One some of the no-decompression air repetitive dives tenders breathed only chamber air for the entire dive.

The only criteria used to evaluate the safety of a particular dive profile was the occurrence of clinical decompression sickness. The determination as to whether or not a particular diver had decompression sickness was made by an experienced U.S. Navy Diving Medical Officer who evaluated both subjective and objective signs and symptoms. If, in the opinion of the examining Diving Medical Officer (based on diver history and physical examination), decompression sickness was present, then appropriate treatment was instituted. No other criteria (such as ultrasonic doppler monitoring) were used to determine whether or not decompression sickness was present. Usually symptoms of decompression sickness would not manifest themselves until the diver surfaced in which case only the stricken diver was treated. In some instances symptoms occurred while still at depth and when the stricken diver could not be isolated in another chamber all the other divers on that particular dive were treated along with the stricken diver. In these cases, the asymptomatic divers were not included in the dive statistics at all while the stricken diver was counted as a case of decompression sickness. All treatments for decompression sickness were done using standard U.S. Navy Oxygen Treatment Tables and Procedures (6) unless otherwise noted.

Test Profiles

A total of 38 different test profiles were used in this dive series and are presented in Tables 1 and 2. These profiles were chosen to cover the depth/time domain of the U.S. Navy Standard Air Tables over the depth range of 50 to 190 FSW. Dives were classified as either bounce dives, repetitive dives, or multi-level dives. Appendix C shows which divers dove on which profile on any given day of the series.

All dives were done using real time decompression profiles generated by a Hewlett-Packard HP 1000 Series Computer using a computer algorithm based on the current version of the EL-MK 15/16 DCM as described below. The computer continuously monitored chamber depth from an Ashcroft Digigauge to an accuracy of ± 1 FSW and updated the diver's decompression status every 2 seconds. Real time algorithms were developed as described elsewhere (1). Real time computation allowed any holds or changes in travel rate during ascent and/or descent to be taken into account thus producing a decompression schedule exactly suited to a particular dive profile. The decompression status was displayed on a video display as the shallowest depth which could be ascended to at any given time without violating the ascent criteria, the so-called Safe Ascent Depth (SAD). During decompression the divers' depth was matched to the SAD which was always computed in 10 FSW increments. The actual dive profiles were continuously recorded and stored by the computer and could be retrieved after the dive. A typical dive profile plot is shown in Figure 1.

When doing real time decompression profiles divers were compressed to the desired depth at a rate of 30 to 60 FSW/min but occasionally holds occurred so mean descent rate varied considerably from dive to dive. In order to keep profiles at a given depth comparable, the actual time for leaving the bottom was determined by Total Decompression Time (TDT). The Hewlett-Packard HP 1000 computer was programmed to compute TDT every 2 seconds along with the SAD. Thus, every 2 seconds the Diving Officer knew exactly how many minutes of decompression would be required if ascent were begun at that instant. Before the dive, a complete set of hard-copy decompression schedules were calculated using the current version of the EL-MK 15/16 DCM assuming a 60 FSW ascent and descent rate. Each one of these schedules had a total decompression time associated with it. Thus, if the planned dive was 190 FSW for 30 min the divers were compressed to 190 FSW and after arrival stayed at 190 FSW until the TDT as calculated and displayed by the HP 1000 computer was the same as that in the previously computed 190 FSW for 30 min hard-copy decompression schedule. At that instant decompression was begun and accomplished by matching diver depth with the SAD. By using this procedure the actual time at depth was adjusted to take total descent time into account such that upon leaving depth the theoretical tissue tensions for controlling tissues were the same as for the profile in the previously computed hard-copy schedule where a

TABLE 1

PROFILE DESCRIPTIONS
(Bounce Dives)

Profile No.	Schedule* Depth/Bottom Time (FSW)/(Min)
Air Dives	
1	50/240
2	60/[66]
3	/100
4	/120
5	/180
6	80/120
7	100/[30]
8	/60
9	/90
10	120/[24]
11	/60
12	/70
13	/80
14	150/[14]
15	/40
16	/60
17	190/[10]
15	/30
16	/40
Constant 0.7 ATA PO_2 in N_2	
20	100/60
21	150/30
22	/40
23	/60
Air → Constant 0.7 ATA PO2 in N2	
24	60/120
25	100/90
26	150/40

*Times in [ ] are no-decompression times.

TABLE 2

PROFILE DESCRIPTIONS
(Repet/Multi-Level Dives)

Profile No.	Schedule
Air Repets*	
No-Decompression	
27	80/ND→(60)→80/ND
28	80/ND→(95)→80/ND
29	80/ND→(180)→80/ND
30	100/ND→(60)→100/ND
31	100/ND→(60)→100/ND→(60)→100/ND
32	120/ND→(60)→120/ND
33	150/ND→(60)→150/ND
Decompression	
34	100/60→(90)→100/40
35	100/60→(90)→100/50
36	150/40→(90)→150/30
Multi-Level Air → 0.7 ATA Constant PO_2 in N_2@	
37	80/60 (Air → 20/180 (0.7 PO_2) → 80/50 (Air)
38	80/60(Air)→20/120(0.7 PO_2)→100/20(0.7 PO2)→ 20/60(0.7 PO_2)→60/40(Air)

* Air Repet Schedules show Depth/Bottom Time with Surface Interval Times in ( ). Depths in FSW, times in minutes.

ND - No-Decompression Dive

@ Schedules show Depth/Time at Depth with Gas Breathed in ( ). Depths in FSW, times in minutes.

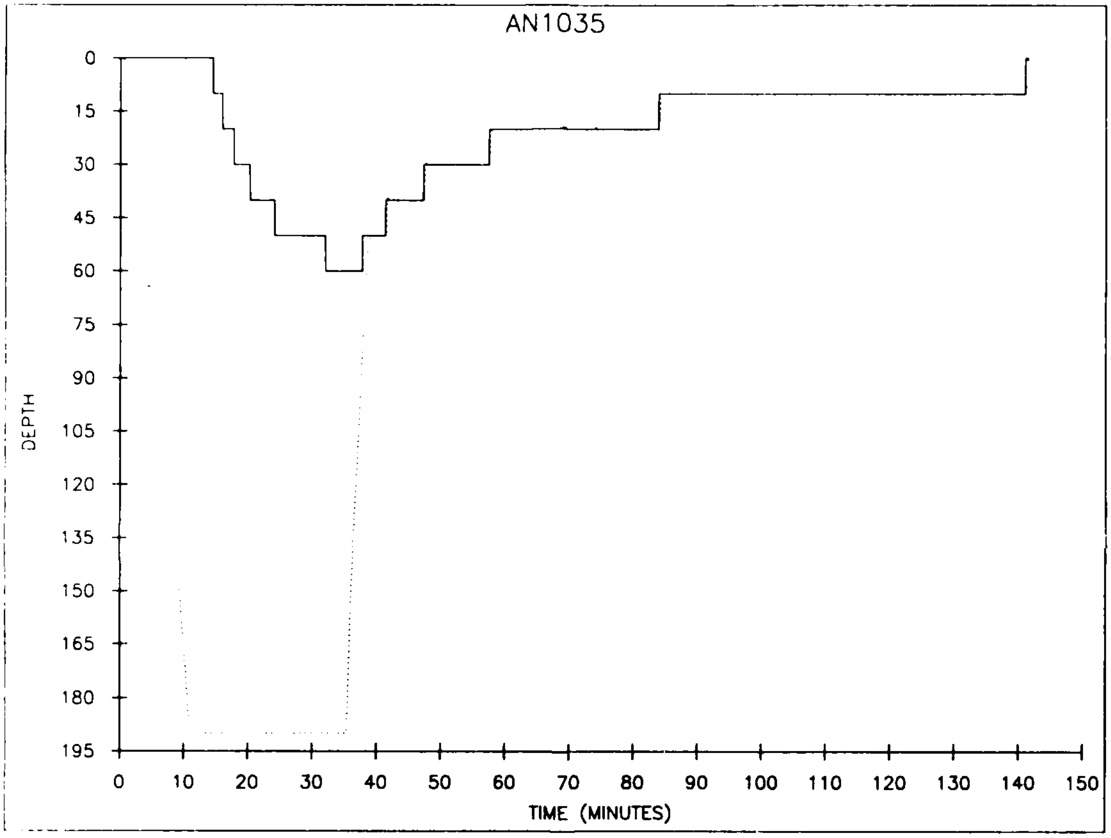


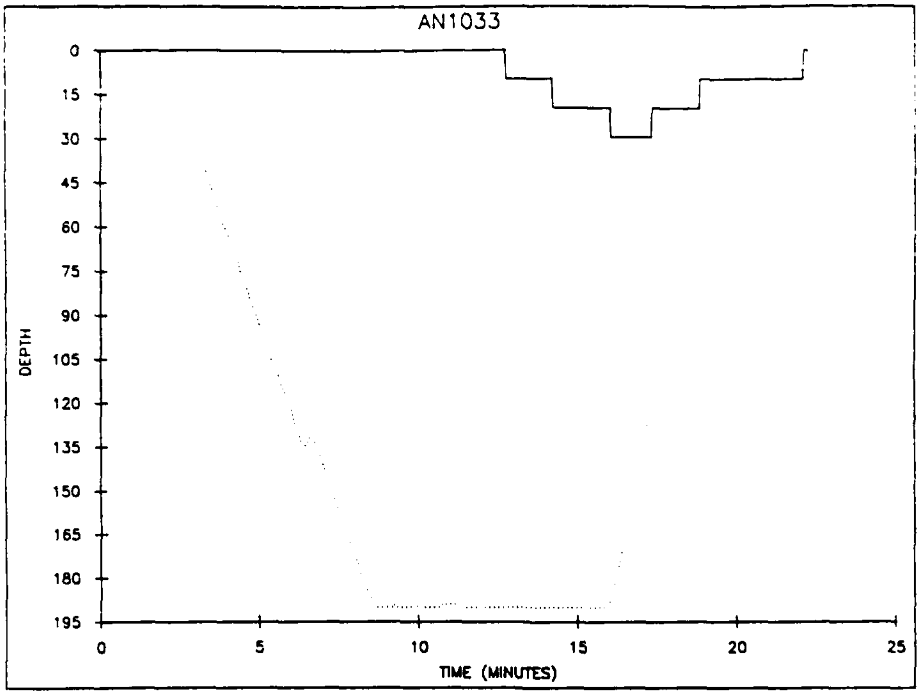
FIGURE 1. Typical Dive Profile. The dotted line shows the actual depth while the solid line shows the Safe Ascent Depth (SAD) as computed by the computer algorithm. Decompression was accomplished by matching actual depth to SAD and following it to the surface. The irregularities noted during compression were due to holds because of ear squeezes. Since the decompression was computed in real time by continuously monitoring chamber depth, all of these irregularities were taken into account in the final decompression schedule.

60 FSW/min descent rate was assumed. Thus, when a 190 FSW/30 min profile is referred to in this report it means a profile where after arriving at 190 FSW divers stayed at depth until the TDT was the same as for a diver who left the surface and traveled to 190 FSW at exactly 60 FPM and stayed at depth for exactly 26.33 min (total bottom time equal to the 3.66 min descent time plus 26.33 min at depth) and ascended at exactly 60 FPM during decompression. Thus, all profiles began ascent at very close to the same theoretical tissue tensions although actual times at depth may have differed by a few minutes depending on the actual descent time.

Decompression stops were in 10 FSW increments. At the 10 FSW stop, the chamber depth was 3 FSW with divers at the bottom of the 7 foot wetpot water column. Since it generally took 30 sec to travel this last 3 FSW, travel was begun when the HP 1000 computer showed 30 sec remaining at the 10 FSW stop. At the instant the HP 1000 showed that the divers could surface, all divers ascended to the surface and immediately began breathing chamber air. This procedure, when followed, always had the divers within 1 FSW of the surface when the HP 1000 showed that they could ascend to the surface. Once the chamber was actually at the surface, divers swam to the ladder and exited the chamber.

In doing no-decompression dives using the real time computer algorithm, the no-decompression time is that time at which the SAD increases from 0 to 10 FSW indicating the need for a decompression stop. As long as the SAD was 0, the divers were within no-decompression limits. Thus, at any given depth no-decompression time was the time remaining before the SAD increased from 0 to 10 FSW and this time was displayed and counted down in 2 sec increments. Programming constraints in the real time environment dictated that this time be computed assuming instantaneous ascent. Thus, once at depth, the no-decompression time was computed by calculating the shortest time it would take any tissue to saturate from its current value to its surfacing tension (10 FSW row of the Maximum Permissible Tissue Tension Tables, Appendix D). Since some tissue offgassing would always occur during ascent, this instantaneous no-decompression time would always be shorter than no-decompression time calculated assuming a finite ascent rate. To take care of this problem, divers were kept at depth until the HP 1000 showed the divers had accumulated approximately a 30 sec stop at 10 FSW. Ascent was begun at that time and if the stop time upon arrival at 10 FSW was more than 30 sec, a stop was taken until the displayed stop time decreased to 30 sec, at which point the chamber was surfaced and divers came to the surface of the wetpot. Stop times less than 30 sec were ignored. This procedure ensured that the real time no-decompression dives were in fact either right at the limits of the model or even slightly beyond model limits (Figure 2).

When doing dives where the U.S. Navy Standard Air Tables were to be used for decompression, a variation on the real time decompression profile procedure was used to take delays during descent into account. During compression, the real time computer program was running and would calculate and update the displayed value for TDT every two seconds, using the current version of the EL-MK 15/16 DCM. The actual time at depth was determined based



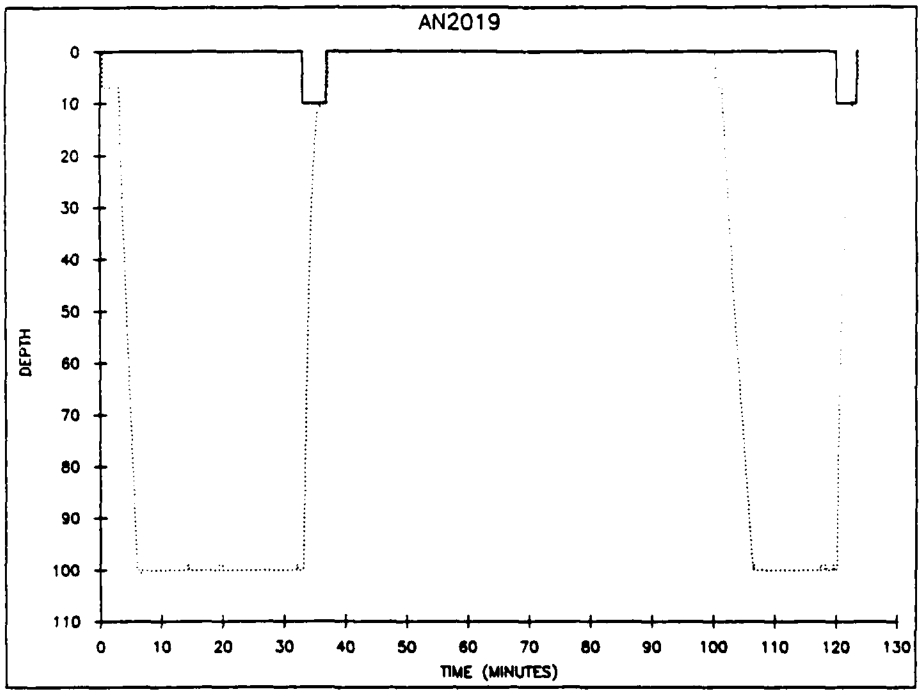


FIGURE 2. No-Decompression Dive Profiles. The profile on top shows a single dive. Upon arrival at 10 FSW there was 1.62 min remaining at this stop. With about 45 sec remaining the chamber was surfaced but the divers remained at 7 FSW in the wetpot until the SAD became 0 FSW at which instant they swam to the surface. The second profile shows a repetitive dive in which ascent was essentially directly to the surface to ensure that divers were at the surface the instant that the SAD decreased to 0 FSW.

on this displayed TDT in exactly the same way as was done during real time decompression profile diving. However, once leaving the bottom a Standard U.S. Navy Air Decompression Schedule was followed to the surface. It should be noted that this procedure was used only to determine when to leave the bottom, not which Standard Air Decompression Schedule to pick. For instance, a dive to 100 FSW for an equivalent 60 min bottom time may have been decompressed on a 100 FSW for 60 min Standard Air Schedule or in other instances on a 100 FSW for 70 min Standard Air Schedule. The reasons for this will be detailed later.

Air dives were accomplished by having divers dress in their wet suits and don a standard air SCUBA apparatus (open-circuit regulator and tank). They then entered the wetpot and remained on the surface until all other divers were in the water. Then, on signal from the Dive Supervisor, all 10 divers went on their SCUBA regulators and swam to the bottom of the wetpot, a depth of 7 FSW. Dive time began at the instant the divers left the surface of the wetpot and at that time the computer program was started. Since the computer monitored the actual chamber depth, it added 7 FSW to all chamber depths to get the actual diver depth.

Once at the bottom of the wetpot (a depth of 7 FSW to mid chest), all divers were instructed to remain upright with their feet just touching the floor of the wetpot. The bicycle ergometer frame heights were such that exercising and non-exercising divers were within 1 FSW depth of each other at mid chest. Thus, the assumed depth error over an entire dive was ± 1 FSW between divers. While on the bottom, divers did not breathe from their SCUBA bottles but breathed from open-circuit SCUBA regulators coming from a manifold piped from the main OSF air bank. Thus, the divers were insured of an unlimited air supply during the dive and only had to breathe from their SCUBA tanks during movements around the wetpot where the regulators on the manifold would not reach.

When doing dives involving the MK 15 UBA (either exclusively or in combination with air breathing) all compressions were done with the divers breathing from the MK 15. Divers donned their UBAs outside of the chamber and breathed chamber air as they entered the water. After entering the water, all divers switched from breathing air to breathing from the MK 15 UBA at the end of a full inspiration and descended to the bottom of the wetpot in unison on signal from the Dive Supervisor, thus ensuring that computer updates regarding breathing gas changes and depth changes corresponded exactly to what the divers were doing in real time. Dive time began when the divers began breathing from the MK 15. Once at depth, the divers either continued breathing from the MK 15 or breathed air from the manifolded SCUBA regulators in the wetpot as called for by that particular dive profile. All gas switches were done in unison on signal from the Dive Supervisor so that the computer could be instructed to change the breathing gas at the instant all the divers actually switched breathing gas. Decompressions were done either breathing air or from the MK 15 as called for by the dive protocol.

Decompression Model and Computer Algorithms

The decompression model used to compute the real time decompression profiles in this study was the Exponential-Linear (EL) version of the model used in developing the computer algorithm for constant 0.7 ATA PO_2 in N_2 diving and is thoroughly described elsewhere (Appendix A of ref. 1). This original decompression model will be referred to as the Exponential-Linear MK 15/16 Decompression Model (EL-MK 15/16 DCM) or the original model. While the decompression model actually encompasses all equations and assumptions considered in the avoidance of decompression sickness (DCS), reference to the EL-MK 15/16 DCM will refer mainly to that portion of the model describing gas uptake and elimination. The other portion of the model which defines the ascent criteria are found in the various Maximum Permissible Tissue Tension (MPTT) Tables which define the maximum gas tension allowed in any of the theoretical halftime tissues at a given depth. Thus, to compute a decompression schedule the EL-MK 15/16 DCM computes tissue tensions based on the particular dive profile and gas uptake and elimination equations then computes decompression stops such that no tissue exceeds its MPTT at any depth. The assumption is that by never having any tissue exceed its MPTT, decompression sickness will be unlikely.

The EL-MK 15/16 DCM was originally developed assuming a constant inspired oxygen partial pressure and assumed that arterial CO_2 tension and venous O_2 and CO_2 tension were constant. Also, venous and tissue oxygen tension are assumed equal. From a physiological standpoint, all these assumptions are reasonable as long as the inspired oxygen tension (PO_2) does not change. However, when breathing air it is the inspired oxygen fraction (FO_2) which is constant and the inspired oxygen tension will be depth dependent. This will also presumably cause venous (and tissue) oxygen tension to vary depending on the arterial tension and the amount of oxygen extracted from arterial blood by the tissue (the a-v oxygen extraction). During this dive series, two modifications of the EL-MK 15/16 DCM were used, the only difference between them being the way in which arterial and venous oxygen tensions are calculated. The original model will be referred to simply as the EL-MK 15/16 DCM while the two modified versions will be referred to as the EL-MK 15/16 DCM-I and EL-MK 15/16 DCM-II. The differences in the way these three versions handle oxygen is summarized in Table 3.

In the original version of the EL-MK 15/16 DCM, inspired and alveolar oxygen tensions were assumed equal and arterial oxygen tension differed only by a constant amount from alveolar. This difference, designated as AMBA02, was assumed to be zero during previous algorithm testing (1). The equation used to compute the alveolar (and arterial) oxygen tension for a constant inspired oxygen partial pressure assumed that the inspired oxygen partial pressure was a dry value, that the inspired and alveolar oxygen fractions were equal and that alveolar gas was fully saturated with water vapor.

In the version EL-MK 15/16 DCM-I, the alveolar oxygen tension was computed from the alveolar gas equation[3]:

TABLE 3

CALCULATION OF ARTERIAL AND VENOUS O_2, CO_2, AND N_2 TENSIONS FOR THE L. MK 15/16 DCM

Site	Original Version	DCM-I Version	DCM-2 Version
Alveolar			
P_{AO_2} (F_{IN_2} Const.)	$(P_{AMB}-P_{H_2O})\cdot(1-F_{IN_2})$	$(P_{AMB}-P_{H_2O})\cdot(1-F_{IN_2})-P_{ACO_2}$	$(P_{AMB}-P_{H_2O})\cdot(1-F_{IN_2})-P_{ACO_2}$
P_{AO_2} (P_{IO_2} Const.)	$P_{IO_2}\cdot(1-P_{H_2O}/P_{AMB})$ [Note 1]	$P_{IO_2} - P_{ACO_2}$ [Note 2]	$P_{IO_2} - P_{ACO_2}$ [Note 2]
P_{ACO_2}	Constant	Constant	Constant
P_{AN_2}	$P_{AMB} - (P_{AO_2} + P_{ACO_2} + P_{H_2O})$	$P_{AMB} - (P_{AO_2} + P_{ACO_2} + P_{H_2O})$	$P_{AMB} - (P_{AO_2} + P_{ACO_2} + P_{H_2O})$
Arterial			
P_{aO_2}	P_{AO_2} - $AMBAO_2$	P_A - $AMBAO_2$	$P_{AO_2}-f(P_{AO_2}, P_{ACO_2}, DAAO_2)$
P_{aCO_2}	P_{ACO_2}	P_{ACO_2}	P_{ACO_2}
P_{aN_2}	P_{AN_2}	P_{AN_2}	P_{AN_2}
Venous/Tissue			
P_{VO_2}	Constant	Constant	$P_{aO_2}-f(P_{aO_2}, P_{aCO_2}, P_{vCO_2}, CAVO_2$
P_{VCO_2}	Constant	Constant	Constant
P_{VN_2}	$P_{AMB}-(P_{VO_2} + P_{VCO_2} + P_{H_2O})$ + PBOVP	$P_{AMB}-(P_{VO_2} + P_{VCO_2} + P_{H_2O})$ + PBOVP	$P_{AMB}-(P_{VO_2}+P_{VCO_2}+P_{H_2O})$ + PBOVP

SYMBOLS

$AMBAO_2$ - Constant alveolar/arterial oxygen tension difference.

$CAVO_2$ - Tissue specific arterial/venous oxygen concentration difference.

$DAAO_2$ - Constant alveolar/arterial oxygen concentration difference.

F_{IN_2} - Inspired nitrogen fraction.

F_{IO_2} - Oxygen fraction (dry) of inspired gas)

f(....) - Function which converts $DAAO_2$ or $CAVO_2$ to a partial pressure difference. Variable in parenthesis are the independent variables. (See text for function description).

P_{AMB} - Ambsolute ambient hydrostatic pressure.

P_A - Alveolar gas tension.

P_a - Arterial gas tension.

PBOVP - Tissue specific gas phase overpressure.

P_V - Venous or tissue gas tension.

P_{H_2O} - Water vapor tension

P_{IO_2} - Inspired oxygen partial pressure.

Note 1 - P_{IO_2} specified as measured in dry atmosphere, i.e. $P_{IO_2} = F_{IO_2}\cdot P_{AMB}$.

Note 2 - P_{IO_2} specified as measured in fully saturated atmosphere, i.e. $P_{IO_2} = F_{IO_2}(P_{AMB}-P_{H_2O})$.

P_{IO_2} cannot exceed $P_{AMB}-P_{H_2O}$ at any depth.

(1) $$P_{A_{O_2}} = P_{I_{O_2}} - \{(P_{A_{CO_2}}/R) - C\}$$

where:

$P_{I_{O_2}}$ = Inspired oxygen tension

$P_{A_{CO_2}}$ = alveolar CO_2 tension

$C = P_{A_{CO_2}} \cdot F_{I_{O_2}} \cdot (1-R)/R$

$F_{I_{O_2}}$ = inspired oxygen fraction

R = respiratory quotient

The value for R was assumed to be 1.0 and the alveolar CO_2 level equal to arterial. In the DCM-I version, the inspired oxygen tension when breathing from the MK 15 UBA (or any other closed-circuit UBA) is assumed measured in an atmosphere fully saturated with water vapor, that is:

$$F_{I_{O_2}} = P_{I_{O_2}}/(P_{AMB}-P_{H_2O})$$

This means inspired oxygen tension can never exceed the difference between ambient pressure and water vapor pressure[4] Arterial oxygen tension was assumed to differ from alveolar by a constant amount and venous oxygen and arterial carbon dioxide tensions were assumed constant.

The second modification of the decompression model (EL-MK 15/16 DCM-II) uses the same method of computing alveolar oxygen levels as used for the DCM-I version. However, in computing the arterial oxygen tension, instead of assuming a constant partial pressure difference between alveolar and arterial gas, a constant oxygen concentration difference is assumed corresponding to the degree of arterial-venous shunting in the lung. Equation 1 is used to obtain the alveolar PO_2 value which is assumed equal to the alveolar capillary PO_2 converted to a concentration in ml/100 using a mathematical representation of the hemoglobin dissociation curve as will be described. The assumed concentration difference due to shunting is subtracted and the resultant concentration converted back to a partial pressure (as will be described) which is then the arterial oxygen tension. In the EL-MK 15/16 DCM-II version the venous oxygen tension is also computed from the arterial tension assuming a constant arterial-venous oxygen concentration difference using the same hemoglobin disassociation curve mathematical representation. The mathematic representation used has been previously published (4) and is:

(2) $$S = (ax^n + bx^{2n})/(1 + cx^n + bx^{2n})$$

where:

S = fractional hemoglobin saturation

a = 0.34332

b = 0.64073

c = 0.34128

n = 1.58678

and:

(3) $$x = (P/P_{50}) \cdot 10^{[0.024(37-T)+0.40(pH-7.4)+0.06 \log (40/PCO2)]}$$

where:

P = oxygen partial pressure (mmHg)

P_{50} = 25 mmHg

T = 37°C

pH = 7.4

P_{CO_2} = CO_2 partial pressure (mmHg)

The values for a, b, c and n in Equation 1 were those from reference (4) which minimized the error in computing the saturation fraction S. (Another set of values was given in reference (4) which minimized the value of P when Equation 1 is inverted but these were not used). In computing a value for x, P_{50}, T and pH where given normal values as shown above and the value for PCO_2 was either the arterial or venous value specified in the MPTT Table. The oxygen concentration in ml/100 ml was computed from the formula:

(4) $$C = S \cdot HBG + 0.003 \cdot PO_2$$

where:

C = oxygen concentration in ml/100 ml

S = fractional hemoglobin saturation from Equation 1

HBG = maximum hemoglobin O_2 capacity (20 ml/100 ml)

0.003 = solubility of oxygen in plasma (ml/100 ml . mmHg)

PO_2 oxygen tension in mmHg[5]

Given a value for PO_2 and PCO_2 the value of C is easily computed using Equations 2, 3, and 4. Once the value for the arterial concentration is computed, the concentration difference due to lung shunting (DAA02) or tissue metabolism for a specific tissue (CAV02), as appropriate, is subtracted. This new concentration is then plugged back into Equation 4 which then must be solved for S. Reference (4) gives the inverse of Equation 2 which would allow straightforward calculation of PO_2 given a value for S. Unfortunately, this inverse equation neglects the solubility factor in Equation 4 which may become significant at increased PO_2 levels. Since Equation 4 cannot be explicitly solved for PO_2, a Newton-Raphson iteration is used to obtain a value which will have an error less than ± 0.01 mmHg. The details of this iteration can be obtained by perusal of Subroutine UPDT1 which is listed elsewhere (5).

In computing changes in inert gas tension, all versions of the EL-MK 15/16 DCM compute all tensions at the ends of linear descents or ascents in one step. However, the equations used to do this assume that the venous oxygen tension will be constant with ascent. When the inspired PO_2 is assumed constant this assumption is valid but when using a constant FO_2 it is not. Furthermore, since the equations used to compute venous oxygen tension for a given arterial value (Equations 2, 3, 4) are not linear, incorporating the changes in venous oxygen tensions into the expression used to compute inert gas tension is not possible. In order to circumvent this problem, the venous oxygen tension is computed at the beginning of ascent or descent and is assumed constant for the duration of the depth change. This results in a small but insignificant error in computing tissue inert gas tension for the ascent and descent rates used in this study.

Ascent Criteria

The EL-MK 15/16 DCM uses a table of Maximum Permissible Tissue Tensions (MPTT Table) to determine what the maximum tissue tensions allowed at each depth are. Generally, ascent to the first decompression stop is done so that most tissues are below their MPTT and one tissue (the controlling tissue) is exactly at its MPTT. Once at the first stop, a time must be spent at this depth until all tissues have offgassed to a value less than or equal to the MPTT for the next shallower stop. This time is the Stop Time. After remaining for the Stop Time, ascent to the next shallower stop is done and another Stop Time computed such that all tissue tensions fall to a value equal to or less than the MPTT valve for the next shallower stop. This process is repeated until the surface is reached. It should be noted that there is no requirement to ascend from a particular stop depth at the instant all MPTT's fall below the values for the next shallower stop. Rather the Stop Time is the minimum time which must be spent at a given depth before ascent is possible. In some cases it may be desirable to remain at a particular stop longer than the Stop Time, such as when taking the last decompression stop at 20 FSW.

All of the MPTT Tables used in this study are listed in Appendix D. The individual tables are referred to by their VVAL number, and certain MPTT Tables were used with only certain modifications of the decompression model.

VVAL18 was used only with the original version of the EL-MK 15/16 DCM and it was this model and MPTT Tables which was used to compute the constant 0.7 ATA PO_2 in N_2 Tables presented in reference 1. The MPTT Tables VVAL22-29 were used only with the DCM-I version and VVAL50-59 used only with the DCM-II version. The body of each MPTT Table in Appendix D gives the maximum tissue tension in FSW[6] which can be present before ascent to the next shallower depth is allowed. The values in the 10 FSW row are the maximum tensions allowed at 10 FSW in order to make a direct ascent to the surface. These 10 FSW values are also known as surfacing values. Subsequent rows give values which cannot be exceeded before ascent to the next shallower stop is allowed, the 20 FSW values indicating maximum values allowed before ascent to 10 FSW and so on. Besides the maximum tensions at each depth the MPTT Tables list several other parameters which are used in computing gas uptake and elimination. The values just under the tissue halftimes are the Saturation Desaturation Ratios or SDR which are used to change the halftimes for offgassing. Below the body of the table are listed a set of Blood Parameters which are constant values used for various blood tensions, tissue overpressures, and oxygen extraction differences. Symbol definitions are given in Table 3 and the values used for these Blood Parameters in various stages of model development are given in Table 9. Details of how all the values in the MPTT Table are used in the decompression model are found elsewhere (1, 5) and certain aspects of their use will be discussed in this report as needed.

The values in the body of the MPTT Table for VVAL18 and VVAL22-29 represent inert gas tensions while those in VVAL50-59 represent total tissue gas tension as will be discussed. In the original EL-MK 15/16 DCM only tissue inert gas tension was assumed to be important but in both modifications (DCM-I and DCM-II) total tissue gas tension, not simply inert gas tension, was assumed to be the critical factor. The venous CO_2 tension was assumed constant in both modifications so the only other tissue tension which varied besides the inert gas tension was the tissue oxygen tension which was assumed equal to the venous tension. The methods of handling the changes in venous oxygen tension were different for the DCM-I and DCM-II modifications.

In the EL-MK 15/16 DCM-I, the venous oxygen tension was (artificially) assumed constant and set at the value it would assume had the inspired oxygen tension been 0.7 ATA. The MPTT Table was then adjusted to take into account the change in venous oxygen tension with depth as the inspired oxygen tension breathing air varied from 0.7 ATA. The starting point for this adjustment was VVAL18, the MPTT Table previously developed for computing the constant 0.7 ATA PO_2 in N_2 Decompression Tables (1). VVAL18 contained values for inert gas tension only, but since the sum of tissue PO_2, PCO_2 and PH_2O were constant, these values differed from total tissue tension by a constant amount which was independent of depth. Thus, by adding this constant value (PVO_2 + $PVCO_2$ + PH_2O) to the inert gas tension computed by the gas uptake and elimination equations and by adding the same value to each of the inert gas tensions in the MPTT Table, the model would then be evaluating total gas tensions but would compute exactly the same decompression tables. When using a constant oxygen fraction gas (such as air) the venous CO_2 and water vapor tensions would remain constant for a given tissue metabolic rate but the venous oxygen tension would vary depending on the arterial oxygen level. In modifying VVAL18 for use with air the first thing that was done was to postulate a metabolic rate for each tissue compartment which would then specify a particular arterial-venous oxygen concentration difference. This concentration difference could then be converted to a partial pressure change using the mathematical representation of the hemoglobin dissociation curve as previously discussed. At each depth, the difference between the venous PO_2 while breathing air and while breathing a constant 0.7 ATA PO_2 could be computed. At a depth of 77 FSW, air has a PO_2 of 0.7 ATA so this difference would be zero. At shallower depths, air has a lower PO_2 than 0.7 ATA so this difference would be negative. That is the venous oxygen tension breathing air would be lower than that breathing a 0.7 ATA PO_2. Deeper than 77 FSW air has a PO_2 greater than 0.7 ATA and the difference would be positive. The inert gas tension is computed as:

$$P_{V_{N_2}} = P_{AMB} - (P_{V_{O_2}} + P_{V_{CO_2}} + P_{H_2O})$$

and as previously mentioned if the arterial oxygen tension is constant, the sum (PVO_2 + $PVCO_2$ + PH_2O) is constant. However, if the tissue oxygen tension is increased above 0.7 ATA, and one desires to keep the total venous gas tension constant, then the PVN_2 must be reduced by exactly the amount hat the PVO_2 increased. Conversely, when breathing air shallower than 77 FSW, the PVO_2 will be decreased and the PVN_2 is increased by that amount to keep total gas tension constant. Initially, a tissue extraction of 2.39 Vol. % was chosen empirically for all tissues based on experimental dive results at different PO_2 levels, as will be discussed later. Based on this, VVAL18 was adjusted by subtracting the difference between the calculated venous oxygen tension on air less the oxygen tension breathing 0.7 ATA PO_2 from each MPTT value. This initial modification of VVAL18 resulted in VVAL22. Although the MPTT Tables VVAL22-29 were modified several times, these venous oxygen tension differences were not changed and are reflected in the difference in MPTT values between VVAL28 and VVAL29. VVAL29 was constructed for a constant PO_2 of 0.7 ATA in the breathing gas and each tissue increases its MPTT exactly 10 FSW for each 10 FSW increase in depth (Appendix D). At 0 FSW, the decrease in venous oxygen tension breathing air was calculated to be 0.76 FSW (17.5 mmHg) less than when breathing a 0.7 ATA PO_2. Thus, the inert gas tension could be increased by this amount and the total gas tension would be constant. The MPTT values at 10 FSW are those which can be safely sustained at 0 FSW but which must be attained before leaving 10 FSW. These are all 0.76 FSW larger in VVAL28 than in VVAL29 reflecting the difference in venous oxygen tensions due to the differences in assumed inspired oxygen tension. As depth increases, the differences between VVAL28 MPTT values and VVAL29 MPTT values decreases and in the 90 FSW row (these are values for leaving 90 FSW or being at 80 FSW) the sign reverses and the VVAL28 MPTT's become smaller than VVAL29 values. Thus, VVAL28 and VVAL29 are the same MPTT's except VVAL28 is adjusted for varying inspired oxygen tensions assuming a constant 21% fraction.

The concept of using total tissue gas tension as the determining factor in causing decompression sickness was used throughout the whole study. When the EL-MK 15/16 DCM-II was instituted, the equations for computing the venous oxygen tensions from inspired (Equations 1 through 4) were included in the model so that the MPTT Table could reflect total inert gas tension for any inspired PO_2. However, in the EL-MK 15/16 DCM-II, values for the postulated arterial venous shunt in the lung along with the postulated arterial venous oxygen concentration difference for each tissue had to be specified. The value for the lung shunt determines the difference between arterial and alveolar oxygen tension and was given a value of 0.17 Vol. % (A 4% shunt assuming a mixed venous oxygen of 40 mmHg and an alveolar value of 100 mmHg on air). This value was assumed independent of inspired oxygen tension. The assumed arterial venous oxygen concentration differences were assumed to be 2.39 Vol. % throughout the study and are shown as the variable CAVO2 in MPTT Tables VVAL50-59 in Appendix D.

The venous CO_2 tension was reduced to 1.87 FSW for all MPTT's (VVAL22-59) from the 2.30 FSW value used in the original EL-MK 15/16 DCM using VVAL18. The arterial CO_2 value was 1.7 FSW for the entire study which was increased from the 1.5 FSW value used with VVAL18. The gas phase overpressures (PBOVP) were adjusted empirically as testing progressed, these were all set to 0 in the original model.

RESULTS

The dive series described here was done in three phases, the first phase being subdivided into two parts. Phase 1A was done over the period from August 23 - September 20, 1984, and Phase 1B from October 3 - October 26. Phase 1 focused mainly on air bound dives but some 38 man dives using a constant 0.7 ATA PO_2 in N_2 were done in the last part of Phase 1B. Phases 1A and 1B consisted of 465 man-dives which resulted in 23 cases of decompression sickness. Results in chronological order are given in Table 4 and detailed descriptions of all cases of DCS are found in Tables B-1 and B-2 of Appendix B. Phase 2 was done over the period from November 5 through November 30, 1984 and consisted of 197 man dives resulting in 17 cases of DCS. This phase consisted of bounce dives, repetitive dives and dives where the breathing gas was changed from air to a constant 0.7 ATA PO_2 in N_2 during decompression. Results in chronological order are given in Table 5 and detailed descriptions of all cases of DCS are found in Table B-3 of Appendix B. Phase 3 went from the 10th through the 20th of December, 1984 and looked mainly at multiple level and repetitive dives. There were 175 man dives done resulting in 9 cases of DCS. There were 175 man dives done resulting in 9 cases of DCS. The chronological results are given in Table 6 and detailed descriptions of all cases of DCS are given in Table B-4 of Appendix B.

The results of all dives grouped according to the type of dive are summarized in Table 7 and 8. There were 612 man dives on bounce profiles resulting in 29 cases of DCS and 225 man dives on repetitive or multiple level profiles resulting in 20 cases of DCS. The entire dive series encompassed 837 man dives resulting in 49 cases of DCS. In Table 8 it should be noted that the two cases of DCS in dive tenders have not been included in the dive results. These will be discussed separately.

The chronological sequence of events as given in Tables 4-6 shows that each phase consisted of more than one type of dive (air no-decompression, decompression, constant 0.7 ATA PO_2, etc.) and it was this sequence of events which influenced changes in the model as testing progressed. In this section the results will be presented according to the type of profile, some of which spanned several phases. The detailed reasons for adjusting the model based on the chronological sequence of events will be presented in the Discussion section of this report.

Air No-Decompression Bounce Dives

Table 7 includes the results of all of the 197 man dives done to test no-decompression limits on air. These schedules are identified as the ones with the bottom times in [ ]. No-decompression limits were tested at 60, 100, 120, 150 and 190 FSW. As previously described, the bottom times for these dives were chosen so that a stop time of at least 30 sec was accumulated at 10 FSW and upon arrival at 10 FSW a stop was taken until the stop time decreased to 30 sec at which time the diver surfaced. Thus, in no case were dives less than the predicted no-decompression limit and in most cases divers surfaced having taken only a portion of the calculated decompression time. All of these conditions were taken to mean that the no-decompression limits were tested under conditions of maximum decompression stress. The no-decompression limits tested were all longer than found it he current U.S. Navy Standard Air Tables (6). The 66 min bottom time at 60 FSW is 6 min longer than current air no-decompression limits, the 30 min time at 100 FSW is 5 min longer, the 24 min time at 120 FSW 9 min longer, the 14 min time at 150 FSW 9 min longer, and the 10 min time at 190 FSW 5 min longer. These increased bottom times ranged from 10% to 100% greater than current air no-decompression bottom times and the fact that no cases of DCS occurred in the 107 man dives is a testament to the safety of the tested no-decompression limits. Table 10 compares the current air no-decompression limits with the tested limits.

Air Decompression Bounce Dives

Table 7 summarizes the results of these dives. Of the dives shown in this table, 367 man-dives were Air Decompression Bounce Dives accounting for all 25 cases of decompression sickness (DCS). Three methods of determining decompression schedules were used. Schedules from the U.S. Navy Standard Air Tables (6) were used for some dives and were usually chosen as the next longer schedule than called for by the actual bottom time of the dive. Choosing the next longer schedule is standard procedure for cold hard-working dives (reference 6, Sect: 7.2.3). There were a total of 4 depth/bottom time combinations on which Standard Air Schedules were used 60 FSW/100 min, 60/180,

TABLE 4

PHASE 1 TEST DIVE RESULTS

Bottom Time (min)* Total Man Dives/DCS (Type)

All Dives on Air Unless Otherwise Noted

DATE (1984)	MOD	50 FSW	60 FSW	100 FSW	120 FSW	150 FSW	190 FSW
PHASE 1-A							
8/23	VVAL22			60 min 20/0			
8/24						60 min 10/1(1)a 1(2)	
8/27			180 min 10/1(1)b	60 min 10/0			
8/28			180 min 10/0				
8/30	STD AIR# 100/70 60/100		100 min 9/0	60 min 9/0			
8/31	100/70			60 min 10/0			
9/4	100/70 VVAL22			60 min 10/0		60 min 10/2(1)c 1(2)	
9/6	60/200		180 min 10/3(1)d				
9/7	100/60 VVAL25		180 min 10/3(1)e 1(2)	60 min 9/0			
9/10	120/70 VVAL25			[30 min] 20/0	60 min 10/1(1)f		
9/13	120/70 VVAL25				60 min 10/0	[14 min] 20/0	
9/17	VVAL26		[66 min] 9/0			40 min 20/1(1)g	
9/20			[66 min] 20/0			40 min 9/1(1)h	
PHASE 1-B	VVAL25						
10/3						40 min 18/0	
10/4				90 min 10/0			
10/5				90 min 9/0			
10/9							[10 min] 19/0 40 min 10/2(1)i
10/12					[24 min] 19/0		30 min 9/0
10/15		240 min 10/0					30 min 10/0
10/16					80 min 10/1(1)j 1(2)		
10/18			120 min 10/0		70 min 10/1(1)k 1(2)		
10/19		240 min 10/0					
10/22	VVAL29@			60 min 19/0			
10/23	VVAL28				60 min 10/1(1)l		
10/25	VVAL29@					30 min 19/0	
10/26	VVAL28		120 min 8/0				

* All Bottom Times include 60 FSW/min descent time. Times in [ ] are no-decompression time.

465 Man Dives
23 Cases DCS

\# Where Standard Air Schedules were used, depth/time of schedule used is indicated in this column, otherwise VVAL number of the MPTT Table used to compute the schedule is shown.

@ VVAL29 dives all constant 0.7 ATA PO_2 in N_2 dives.

Letters Key DCS to Description in Appendix B.

TABLE 5

PHASE 2 TEST DIVE RESULTS

Bottom Time (min) or Profile No.* Total Man Dives/DCS (Type)

All Dives on Air Unless Otherwise Noted

DATE (1984)	MOD	80 FSW	100 FSW	120 FSW	150 FSW	1[illegible] FSW REPETS	150 FSW REPETS
11/5	VVAL29@		60 min 8/0				
	VVAL28				40 min 10/1(1)m		
11/6	VVAL29@				60 min 9/2(1)n		
11/8	VVAL28			60 min 19/0			
11/9	VVAL29@				40 min 8/0		
11/12					40 min 18/2(1)o		
11/13	VVAL29						No. 36 7/0
11/14						No. 35 9/2(1)p 1(2)	
11/15	VVAL50						No. 36 9/2(1)q
11/16	VVAL52					No. 34 8/1(1)r	
11/19	VVAL52		90 min 19/0				
11/20	Air→0.7 ATA PO_2				40 min 9/0		
11/26					40 min 10/0		
11/26	VVAL52					No. 30 10/2(1)s	
11/27	VVAL53	120 min 8/0					
11/28	VVAL54					No. 30 10/3(1)t	
11/29		120 min 10/1(1)u					
11/30	VVAL55					No. 30 16/0	
							197 Man Dives 17 Cases DCS

* All Bottom Times include 60 FSW/min descent time.
Profile No. refers to Table 2.

@ VVAL29 dives all constant 0.7 ATA PO_2 in N_2.

Letters Key DCS to Description in Appendix B.

TABLE 6

PHASE 3 TEST DIVE RESULTS

Bottom Time (min) or Profile No.* Total Man Dives/DCS (Type)

All Dives on Air Unless Otherwise Noted

DATE (1984)	MOD	60 FSW Air→0.7 PO2	80 FSW REPETS	100 FSW REPETS	120 FSW REPETS	150 FSW REPETS	MULTI-LEVEL Air→0.7 PO2
12/10	VVAL56		No. 29 20/1(1)v#				
12/11	VVAL58		No. 28 10/1(1)w	No. 31 10/2(1)x#			
12/12			No. 27 10/0	No. 31 9/0			
12/13			No. 28 10/1(1)y No. 29 9/0@				
12/14			No. 27 10/0				No. 38 10/1(1)z
12/17	VVAL59				No. 32 10/0		No. 37 10/1(1)aa 1(1)
12/18						No. 33 10/0$	No. 38 8/1(1)bb
12/19					No. 32 10/0		No. 37 10/0
12/20		120 min 19/0					
							175 Man Dives 9 Cases DCS (plus 2 in Tenders not shown)

* All Bottom Times include 60 FSW/min descent time
Profile No. refers to Table 2.

\# DCS in Tender not shown. See text and Table B-4.

@ 10 divers completed 1st dive.

$ Bottom Time of 2nd dive 2 min longer than planned because of technical error

Letters Key DCS to Description in Appendix B.

TABLE 7

RESULTS OF BOUNCE DIVES TESTED

AIR

Profile No.	Depth/Time# (FSW)/(min)	Std. Air	VVAL22	VVAL25	VVAL26	VVAL28	VVAL53 /54	TOTALS
1	50/240					20/0		20/0
2	60/[66]				29/0			29/0
3	/100	9/0 a						9/0
4	/120					18/0		18/0
5	/180	10/3 b	20/1	10/4				40/8
6	80/120						18/1	18/1
7	100/[30]			20/0				20/0
8	/60	38/0 c	30/0					68/0
9	/90					19/0		19/0
10	120/[24]					19/0		19/0
11	/60	20/1 d				29/1		9/0
12	/70					10/2		18/0
13	/80					10/2		10/2
14	150/[14]			20/0				20/0
15	/40				29/2	28/1		57/3
16	/60		20/5					20/5
17	190/[10]			20/0		19/0		19/0
18	/30					19/0		19/0
19	/40					10/2		10/2
TOTALS		77/4	70/6	50/4	58/2	20/8	18/1	474/25

a - 60/100 Std. Air Schedule Used.
b - 60/200 Std. Air Schedule Used.
c - 9/0 Using 100/60 Std. Air Schedule.
29/0 Using 100/70 Std. Air Schedule.
d -120/70 Std. Air Schedule Used.

#-Times in [ ] are no-decompression times.

CONSTANT 0.7 ATA PO_2 in N_2

20	100/60	All Dives Used VVAL29	27/0
21	150/30		19/0
22	/40		26/2
23	/60		9/2
TOTALS			81/4

AIR → CONSTANT 0.7 ATA PO_2 IN N_2

24	60/120	VVAL59	19/0
25	100/90	VVAL52	19/0
26	150/40	VVAL52	19/0
TOTALS			57/0

TOTALS OF ALL BOUNCE DIVES 612/29

TABLE 8

RESULTS OF REPETITIVE/MULTI-LEVEL DIVES TESTED

Profile No.	VVAL28	VVAL50	VVAL52	VVAL54	VVAL55	VVAL56	VVAL58	VVAL59	TOTALS
				↓ AIR ↓					
27							20/0		20/0
28							20/2		20/2
29						20/1#	9/0		29/1
30			10/2	10/3	16/0				36/5
31							19/2#		19/2
32								20/0	20/0
33								10/0	10/0
34			8/1						8/1
35	9/3								9/3
36	7/0	9/2							16/2
Total Air Repetitive Dives									187/16
			↓ AIR → CONSTANT 0.7 ATA PO_2 in N_2 ↓ Multi-Level						
37								20/2	20/2
38							10/1	8/1	18/2
Total Multi-Level Dives									38/4
Total All Dives	16/3	9/2	18/3	10/3	16/0	20/1	78/5	58/3	225/20

DCS in Tender Not Shown. See Text and Table B-4.

TABLE 9

ASCENT CRITERIA BLOOD PARAMETERS

All values in FSW except for those in parenthesis ( ) which are in Volume %.

	$P_{A_{CO_2}}$	P_{H_2O}	PV_{CO_2}	P_{VO_2}	$AMBAO_2$	PBOVP	ΔP/ΔP#
VVAL18	1.5	0.0	2.30	2.0	0	0	10
VVAL22 -28	1.7	2.0	1.87	2.8	2.46	10	10@
VVAL29	1.7	2.0	1.87	2.8	2.46	10	10
				CAVO2	DAAO2		
VVAL50	1.7	2.0	1.87	(2.39)	(0.17)	10	10
VVAL52 -59	1.7	2.0	1.87	(2.39)	(0.17)	7-36*	10

Increase in MPTT for every 10 FSW depth increase.

@ Values adjusted at each depth for changing PO_2, see text.

* Different PBOVP specified for each tissue, see Appendix D.

The Surfacing tissue Tensions, and Saturation Desaturation Ratios (SDR's) were varied according to dive results. PBOVP values were changed for VVAL52-59 only.

For Symbol Definition, see Table 3.

TABLE 10

NO-DECOMPRESSION LIMIT COMPARISONS

Depth (FSW)	USN Standard Air Limits	Tested Limits	Final VVAL59 Limits
30	360#		∝
40	200		167
50	100		88
60	60	66	61
70	50		47
80	40		39
90	30		31
100	25	30	26
110	20		22
120	15	24	20
130	10		18
140	10		16
150	5	14	14
160	5		12
170	5		10
180	5		9
190	5	10	9

360 min was the maximum time anticipated in developing USN Standard Air Decompression Limits.

100/60, and 120/60. The next longer Standard Air Schedule was for all the 60 FSW/180 min depth/bottom time dives, all the 120/60 dives and 29 man dives at 100 FSW for 60 min. The Standard Air Schedule with the actual bottom dove was used for the 60/100 and 9 man-dives on the 100/60 depth/bottom time combinations. The EL-MK 15/16 DCM-I was used to compute all VVAL22-28 schedules and the EL-MK 15/16 DCM-II was used for the VVAL53/54 schedules as shown in Table 7.

The success of the Standard Air No-Decompression Limits are in contrast to the abysmal failure of some of the Standard Air Decompression Tables. The most notable is the 60/180 dive which was decompressed on the 60/200 Standard Air Schedule. Appendix E shows that this added 14 min to the total decompression time (TDT) compared to the 60/180 Standard Air Schedule but the 3 cases of DCS in 10 man dives testify that this increase was insufficient (Table 4, Table 7). VVAL25 added another 40 min of decompression time but the DCS rate was increased to 4 cases in 10 man dives. One of these cases (subject 110, Table B-1 Appendix B) was a particularly resistant case of shoulder pain. A further increase of 42 min of TDT using VVAL22 reduced the DCS incidence to 1 in 20 man-dives but even this small incidence was surprising considering that the TDT had been increased by a factor of 2.15 over the 60/200 Standard Air Schedule and 2.68 over the 60/180 Standard Air Schedule.

In stark contrast was the experience using the 100 FSW Standard Air Schedules on the 100 FSW/60 min depth/time dives. After doing 29 DCS free dives on the 100/70 Standard Air Schedules, 9 man-dives were done using the 100/60 Standard Air Schedule without experiencing any DCS. The initial study design had VVAL22 schedules being tested first and in retrospect the 100 min TDT was much longer than required. The 100/70 Standard Air Schedule became one of the benchmark schedules and as the decompression model MPTT Tables were modified, it was always done with trying to get the resultant model to predict a decompression schedule for a 100 FSW/60 min dive with the same TDT as the 100/70 Standard Air Schedule.

The 120/70 Standard Air Schedule was reasonably successful in decompressing a 120/60 dive with only one mild shoulder pain in 20 man-dives. Increasing the TDT to 147 min using VVAL28 decreased the DCS incidence only slightly to 1 in 29 man-dives. The same MPTT, however, produced a considerable incidence of DCS when used to decompress from dives having a 80 and 70 min bottom time at 120 FSW (Tables 4, 7).

The 150 FSW depth was considered important because that was the deepest depth used in the testing of the 0.7 ATA constant PO_2 in N_2 decompression model (1). The VVAL22 air schedule as computed was over 2.5 times longer than the Standard Air Schedule but the 5 cases of DCS in 20 man-dives showed this increase was not adequate. When the bottom time at 150 FSW was reduced to 40 min, VVAL26 proved inadequate giving rise to 2 cases of DCS in 29 man-dives with a TDT over 1.4 times longer than the Standard Air Schedule. VVAL28 reduced the DCS incidence to 1 in 28 man-dives with a TDT 1.62 times longer than the 150/40 Standard Air Schedule (Appendix E, Table E-1).

By the end of Phase IA the modifications to the MPTT Tables were being heavily influenced by the success of the no-decompression limits, the success of the 100/70 Standard Air Schedule and the fact that the 60/180 schedule as computed by VVAL22 did not appear overly conservative although it was 2.68 times longer than the Standard Air Schedule. The search was on for a model which would; (1) Retain the previously tested no-decompression limits, (2) Predict a decompression schedule for a 100/60 dive with a TDT the same as for the 200/70 Standard Air Schedule and, (3) Keep the 60/180 schedule with the same TDT as computed by VVAL22. In addition, it should lengthen the TDT for 150/60 dives beyond those predicted by VVAL22. VVAL28 was derived to fulfill these criteria but succeeded only partially as shown in Appendix E. The 100/60 schedule was only 2 min longer than the Standard Air 100/70 Schedule but the 60/180 Schedule TDT increased 23 min over that predicted by VVAL22. Also the 150/60 schedule had 10 min less TDT than the previously unsafe VVAL22 schedule. In spite of these deficiencies it was used as a starting point for Phase 1B and indeed survived until the end of Phase 1.

Its success on the 50/240 dive showed, if anything, it was too conservative for this long shallow dive. VVAL28 predicted a schedule 11 min shorter than the VVAL22 schedule for a 60/120 dive but produced no DCS in 18 man-dives. At 190 FSW safe decompression could not be accomplished using VVAL28 until the bottom time was shortened from 40 to 30 min even though the 40 min schedule was 2.22 times longer than the Standard Air Schedule and the 30 min schedule only 1.57 times longer.

By the end of Phase 1B, all air bounce diving had been completed except for one 80 FSW schedule for 120 min which was tested at the end of Phase 2 (Table 5). Although this schedule was dove using two different VVAL's (53 and 54) the profiles differed by only 1 min so the results were lumped together. In spite of increasing the TDT by a factor of 2.9 over the Standard Air Schedule there was 1 case of Type 1 DCS in 18 man-dives.

The 60 FSW/100 min dive done using the Standard Air Schedules started out as a 60/180 dive but was aborted for technical reasons after 100 min. There was no DCS in any of the 9 divers but the schedule was not tested again because of time constraints.

Table 11 summarizes the raw and expected binomial incidences of the air dives. The first line shows no-decompression dives and the second all Air Bounce Dives. Since the 60/180 using the Standard Air Schedules and VVAL25 would fall outside the limits of the final model, these dives (and resulting DCS) can be excluded dropping the expected incidence as shown in the third line. Also, if one restricts the diving depth/bottom domain to 120/60, 150/40, and 190/30 another 50 man-dives and 11 cases of DCS can be eliminated, resulting in an overall expected incidence of 3.2%. However, all the DCS resulted from decompression dives and if these are separated from no-decompression dives, the expected incidence is 4.2% while for no-decompression dives it is 2.7% (Table 11).

Constant 0.7 ATA PO2 in N2 Bounce Dives

All of the 0.7 ATA constant PO_2 in N_2 dives were done using VVAL29 and the EL-MK 15/16 DCM I during the last week of Phase 1B (Table 4) and the first

TABLE 11

DECOMPRESSION SICKNESS INCIDENCE

Dive Type		Man-Dives	DCS	Incidence Raw	Incidence Binomial (95% Confidence)
No-Decompression Air		107	0	0.0%	2.7%
All Air Bounce Dives		474	25	5.3%	7.1%
Exclusive of 60/180 on VVAL25 & Std. Air		454	18	4.0%	5.8%
Limited Depth/Time Domain*	(All)	404	7	1.7%	3.2%
	(Decomp. Only)	297	7	2.4%	4.2%
All 0.7 ATA N2O2 Dives		81	4	4.9%	11.3%
Limited Depth/Time Domain#		46	0	0.0%	6.3%
Air → 0.7 ATA Bounce Dives		57	0	0.0%	5.1%
No-Decompression Repetitive Dives		154	10	6.5%	11.0%
All Repetitive Dives		187	16	8.6%	12.0%
Exclusive of Profile 30 on VVAL52 & 54		134	5	3.7%	7.2%

* Maximum Depth/Time Limits: 60/180, 100/90, 120/60, 150/40, 190/30

Maximum Depth/Time Limits: 100/60, 150/30

week of Phase 2 (Table 5). As previously described in the Ascent Criteria portion of the Methods Section, VVAL29 is VVAL28 adjusted for the theoretical differences in venous PO_2 breathing a constant 0.7 ATA PO_2 compared to air at the various depths. Thus, VVAL28 and VVAL29 represent the same decompression model. The results of all dives are summarized in Table 7. A complete set of 0.7 ATA O_2 in N_2 schedules using the EL-MK 15/16 DCM and VVAL18 had already been previously tested and published (1, 8).

The 100 FSW/60 min schedule produced no DCS in 27 man-dives in spite of a 28% (18 min) reduction in TDT from the previously tested VVAL18 schedule (2) (Table E-2, Appendix E). The success of this reduction was particularly gratifying because during the original testing of the 0.7 ATA PO_2 in N_2 Decompression Tables (8), a schedule having a TDT 8 min longer than the VVAL29 schedule gave 1 case of DCS in 10 man-dives. This previously tested MVAL5 schedule (reference 1, Profile 8, Appendix C) did, however, have decompression stops beginning at 50 FSW, some 20 FSW deeper than the first stop for the VVAL29 schedules.

A 150 FSW/30 min schedule produced no DCS in 19 man-dives in spite of a 30 min (46%) reduction in TDT from the previously tested VVAL18 schedule (1). In the original testing of the constant 0.7 ATA O_2 in N_2 decompression schedules, attempts had been made to develop a safe 150/60 schedule which were abandoned due to time constraints and a high incidence of DCS (1, 8). During Phase 1 of this earlier testing (1) schedules with about 130-135 min TDT appeared safe but later produced an unacceptable incidence of DCS. While the final VVAL18 schedules contained a 150/60 schedule, this was not tested and the bottom time restriction at 150 FSW was set as 30 min. Since the untested VVAL18 schedule had a TDT 77-86 min longer than the earlier 150/60 schedules which had been previously tested and since VVAL29 predicted a further 5 min increase in TDT it was thought that this 150/60 schedule would prove successful. The two cases of DCS in 9 man-dives using VVAL29 showed this increase was not adequate and shortening the bottom time to 40 min reduced the DCS incidence to 2 cases in 26 man-dives which was, however, still unacceptably high. So in the end, reduction in TDT were possible within the previously determined depth/time restrictions applied to VVAL18 (1) without an increased incidence of DCS. Profiles tested outside of this restriction at 150 FSW still produced an unacceptably high incidence of DCS. The final version of the decompression model (VVAL59) resulting from testing in this study would have lengthened the TDT for the 150/60 profiles by another 60 min but time was not available to test this profile. Table 11 shows the expected incidences of DCS based on the limited testing of these constant 0.7 ATA PO_2 schedules but the number of dives was too small to obtain significant predictions.

<u>Air → Constant 0.7 ATA PO2 in N2 Bounce Dives</u>

Up through the middle of Phase 2, testing of the decompression model in real time switching from a constant fraction to a constant percentage of oxygen would not have been possible since the MPTT Tables had to be adjusted to suit the two different conditions. With the introduction of the EL-MK 15/16 DCM-II, a single MPTT Table would suffice for both conditions so testing could progress.

Initial testing using VVAL52 focused on 100 FSW and 150 FSW at the maximum bottom times which produced safe profiles on air dives. In all of these dives, a constant 0.7 ATA PO_2 was breathed from the MK 15 UBA during descent then air was breathed from arrival on the bottom to arrival at the first stop. At the first stop, a switch was made back to the constant 0.7 ATA PO_2 in N_2 breathing medium of the MK 15 and this was breathed to the surface. No DCS was observed on the 100 FSW and 150 FSW profiles (Table 7) in spite of some impressive reductions in TDT. VVAL52 reduced the TDT for the 100/90 schedule with breathing gas switching by 42% compared to the VVAL28 air schedule (Table E-1, E-2; Appendix E). The TDT for the 150/40 profile with breathing gas siwtching was reduced 39% compared to a schedule breathing air throughout.

The 60 FSW/120 min profiles was tested with breathing gas switching because VVAL59 predicted a 42% reduction in TDT compared with the previously tested VVAL28 schedule on air while for the 60/180 schedule the reduction was only 33% compared with the previously tested VVAL22 air profile (Appendix E). No cases of DCS resulted from the 19 man-dives on this schedule.

The overall results of switching to the higher PO_2 during decompression showed that the EL-MK 15/16 DCM-II could adequately handle these PO_2 changes. The overall impression from the dive series is that further reductions may have been possible but unfortunately, time was not available for further testing of these profiles. Table 11 shows the expected incidences for this limited testing.

Air Repetitive Dives

Testing of Air Repetitive Dive profile began in Phase 2 (Table 5) and continued through Phase 3 (Table 6). A total of 187 man-dives were done resulting in 16 cases of DCS and the results are summarized in the the top portion of Table 8. A total of 10 different repetitive dive profiles were used (Table 2) with 7 being no-decompression and 3 being decompression. The no-decompression profiles were constructed such that both the effects of increasing depth and increasing surface interval could be tested. A series of two no-decompression repetitive dives separated by a 60 minute surface interval at 80, 100, 120 and 150 FSW was used to test the effect of increasing depth. Three different surface intervals at 80 FSW served to test the effect of increasing surface interval time. Finally, three successive no-decompression dives at 100 FSW were done to see if the model could handle multiple repetitive dives.

Table E-3 of Appendix E compares the various no-decompression profiles. For all profiles computed by the decompression models tested in this study the no-decompression times for each dive are given in the appropriate "Excursion" column. The first two line entries for each profile show two Standard Air

Table comparisons. The first line shows what the no-decompression times for each excursion would have been if Standard Air Repetitive diving procedures had been followed. If the Residual Nitrogen Time was greater than the no-decompression time, this difference is shown as a negative number. The second line of the "Std Air" entry for each profile shows the amount of decompression time which would have been required for the bottom time enclosed in { }. The first column {bottom time} entry shows a typical bottom time actually used in testing. The TDT is given in the TDT column. In succeeding columns the {bottom time} is shown with the Residual Nitrogen Time as determined by the Standard Air Repetitive Diving Procedures enclosed in [ ]. The TDT for the Standard Air Decompression schedule with a time equal to the sum of the {bottom time} and [Residual Nitrogen Time] is given in the TDT column.

Table E-4 compares the decompression schedules for the three decompression repetitive dive profiles tested, the decompression schedules for the first and second dives shown in the appropriate column.

Decompression Repetitive Dives:

The first repetitive dive profiles tested were the repetitive decompression profiles at 100 and 150 FSW, Profiles 34, 35 and 36. These profiles were tested during the transition from the EL-MK 15/16 DCM-I to the EL-MK 15/16 DCM-II. VVAL50 was the first MPTT used with the EL-MK 15/16 DCM-II and was calculated to give decompression profiles as close to VVAL28 (using the DCM-I version) as possible.

The 150 FSW repetitive decompression profile (#36) initially appeared safe, resulting in no DCS in 7 man-dives using VVAL28. When dove again on VVAL50, however, two mild Type I DCS occurred after the second dive (Table 5, Table B-3, Appendix B). Unfortunately, the VVAL28 and VVAL50 profiles were not identical although the small differences were thought to be insignificant. Compared to the Standard Air Profile, however, the decompression times for both the VVAL28 and the VVAL50 profile were considerably longer. The TDT for the first dive was 63% to 69% longer for the computed tables compared to Standard Air Tables and for the second dive 82% to 77% longer. On the first dive the decompression stops as computed using the Decompression Models began 10 FSW deeper and were longer at every depth than the Standard Air Table but for the second dive, the decompression model predicted a shallower first stop and a much longer 10 FSW than the Standard Air Table.

The first 9 man-dives on the 100 FSW Profile #35 produced 3 cases of DCS. One of these occurred during the surface interval but the diver did not report it and made the second dive after which the pain recurred. Another of the cases of DCS occurred at the 10 FSW stop of the second dive. VVAL52 was created which increased the TDT for both portions of Profile #35. However, in order to keep testing within a reasonable working day, the second bottom time of 50 min was reduced to 40 min resulting in Profile #34, which in spite of the shorter repetitive bottom time had almost the same TDT as Profile #35.

The DCS incidence was 1 case in 3 man-dives but the pain only symptom occurred at 70 FSW during ascent from the first dive. The circumstances of this symptom (Table B-3, Appendix B) were very unusual and further testing of this profile would have been carried out had time allowed. Like Profile #36, Profiles #34 and #35 predicted significantly longer decompressions than Standard Air Tables for both the first and second dives as shown in Table E-4 of Appendix E.

The overall raw incidence of DCS for the three repetitive decompression profiles was 6 cases in 33 man-dives or 18%. However, the number of trials was too small to draw any statistically significant inferences from them.

No-Decompression Repetitive Dives:

Initial testing of the no-decompression repetitive dives began at the end of Phase 2 with the double 100 FSW Profile #30 (Table 2). The initial dive using VVAL52 used the previously tested 30 min no-decompression limit which had produced no DCS in 20 man-dives. However, of the 2 cases of DCS which occurred on the first 10 man-dives, one was during the surface interval. VVAL54 shortened the first no-decompression limit by over 1 min and shortened the second no-decompression time by almost 2.5 min (Table E-3, Appendix E) but this resulted in 3 cases of DCS in 10 man-dives. The disconcerting thing here is that all three symptoms occurred after the 1st dive, and none of the seven subjects who completed the second dive had any symptoms. There was no procedural reasons which accounted for this rash of DCS on a schedule previously thought to be safe except that these dives were done late in the Phase 2 studies and diver fatigue may have played a role. This phenomenon had been seen previously during Phase I testing of the constant 0.7 ATA PO_2 in N_2 Decompression Schedules (8). At the end of Dive Series I of this previously reported testing, the DCS incidence on profiles having had 25-27 DCS-free dives increased for no apparent reason (reference 8, Table 3) and diver fatigue was postulated.

The next MPTT used for the 100 FSW no-decompression repetitive dives was VVAL55 which reduced the first no-decompression time to 26.5 min (only 1.5 min longer than the Standard Air Table limit) but increased the second no-decompression limit to just over 20 min. Two of the divers who suffered DCS on the VVAL54 schedule dove the VVAL55 schedule (Table C-3, Appendix C) and there was no DCS in 16 man-dives.

In testing the triple 100 FSW repetitive dive (Profile #31), VVAL58 retained the 26.5 min no-decompression time for the first dive but reduced the second to 17.74 min. This no-decompression time was only reduced an additional 1.85 min for the third dive. The two cases of DCS which occurred in the 19 man-dives performed both occurred after completion of the third dive. However, there was a bizarre case of DCS in the dive tender (Subject #122) who was in a warm dry chamber some 7 FSW shallower than the diver subjects for the entire dive (Table B-4, Appendix B). This individual had participated as a diver subject in Phase 1B (Table C-2, Appendix C) and made 8 dives resulting in 1 case of DCS after a 120/70 dive on VVAL28 (Table B-2, Appendix B).

The double dive no-decompression profiles with a 60 min surface interval at 80, 120 and 150 FSW (Profiles #27, 32 and 33) produced no DCS in 50 man-dives. If one combines these results with the 16 DCS-free dives on the 100 FSW profile (#30) using VVAL55 the expected incidence assuming a binomial distribution is 5.2% at the 95% confidence level. The savings in decompression time on these profiles are substantial as shown in the comparisons of Table E-3 of Appendix E. On the 80 FSW profile (#27) the no-decompression limit for the second dive was almost tripled and 19 min of decompression time saved compared to Standard Air Tables. On the 100 FSW profiles, the 26 min Residual Nitrogen Time resulting from the first dive would have precluded no-decompression diving on the second if Standard Air Tables had been used. The EL-MK 15/16 DCM-II saved some 28 min of TDT on the second and 39 min on the 3rd dive. Similarly, for the 120 and 150 FSW profiles, the Standard Air Tables would have required decompression from both the first and second dives for bottom time tested. As far as the 60 min surface interval double repetitive dives are concerned, it appears substantial amounts of decompression time required by the Standard Air Tables can be safely eliminated. The ability of the decompression model to safely handle a third no-decompression repetitive dive was not sufficiently tested.

The ability of the EL-MK 15/16 DCM-II to handle 80 FSW no-decompression repetitive dives with surface intervals greater than 60 min is not as clear cut. With a 95 min surface interval (Profile 28), VVAL58 increased the no-decompression time for the second dive by 32%. This 30 min bottom time was 18 min longer than allowed by the Standard Air Tables. Two mild cases of DCS occurred in 20 man-dives. After a 180 min surface interval (Profile 29), the no-decompression time for the second dive had increased to within a minute of the initial dive limit using VVAL56 and one case of Type I DCS occurred in 20 man-dives. However, one of the trunk tenders suffered Type I symptoms in spite of being in a warm chamber and 7 FSW shallower than the diver subjects. This subject (#118) had made 13 dives during Phase 1B and 2 (Table C-2, 3; Appendix C) and suffered only 1 case of Type I DCS. He was breathing air throughout and was warm. After this incident, dive tenders began breathing mixes with PO_2 levels higher than air during these types of dives. VVAL58 shortened the second no-decompression time by about 2 min compared to VVAL56 and produced 9 DCS-free dives. Considering that the one case of DCS on VVAL56 was mild and that VVAL58 had shortened the second no-decompression limit, no further testing of Profile #29 was done.

Table 11 summarizes the DCS incidences for the air repetitive dives. Overall there was an 8.6% raw incidence of DCS. The three decompression profiles (34, 35, 36) resulted in 6 cases of DCS in 33 man-dives (18% raw incidence) but were considerably lengthened by the final VVAL59 MPTT. Unfortunately, time for retesting them was not available. If one just looks at the no-decompression repetitive dives, excluding the decompression dives, the raw incidence drops to 6.5% but the expected incidence drops only slightly. Profile #30, using VVAL52 and 54, was considerably changed by VVAL55 resulting in a lowered DCS incidence. Excluding these VVAL52 and 54 dives, the expected incidence for no-decompression repetitive dives drop to 7.2%.

The overall results of the testing of the Air No-Decompression Repetitive dives indicated that considerable amounts of decomprression could be saved compared to the requirements of the Standard Air Tables. This is in contrast to the decompression repetitive dives where substantial increases in TDT were required compared to the Standard Air Tables. The two cases of DCS in the tenders during no-decompression repetitive dive testing was disturbing, however, and may indicate that increased gas uptake in the warm chamber environment more than offset the 7 FSW depth advantage of the tenders.

Multi-Level Air/Constant 0.7 ATA PO2 in N2 Dives

There were two long multiple level dive profiles tested, both designed to see if the EL-MK 15/16 DCM-II would work with combined depth changes and breathing gas switches. Both of these profiles (#37, #38 Table 2) are essentially two dives on air separated by a 180-200 min interval breathing 0.7 ATA PO_2 at 20 FSW. Profile #38 had a 20 min downward excursion to 100 FSW after 2 hrs at 20 FSW. Unfortunately, time was not available to test these profiles using air throughout so the DCS incidence on air is unknown. Profile #38 was first tested using VVAL58 which resulted in a single case of Type I DCS which did not respond rapidly to treatment (Table B-4, Appendix B). The Multi-Level Profiles were such that none of the intermediate excursions required decompression stops, so changing the MPTT's would only change the decompression to the surface from the last excursions. Table E-5 of Appendix E shows the final decompression schedule which has only a single decompression stop at 10 FSW. VVAL59 lengthened the TDT from the final 60 FSW excursion of Profile 38 by 7 min compared to VVAL58 but the incidence of DCS remained essentially unchanged with 1 case in 8 man-dives. Again this was a Type I symptom which did not respond rapidly to compression to 60 FSW (Table B-4, Appendix B). Profile #37 produced 2 cases of DCS in 20 man-dives one of which occurred 72 hours after completion of the dive. During testing of these multi-level dives, 3 out of the 4 cases of DCS which occurred had recurrences during treatment which required recompression.

There are no currently available procedures for computing decompression schedules for dives of this type except to use a Standard Air Schedule with the total bottom at the maximum depth as shown in the "Std Air" entry in Table E-5 of Appendix E. Profile #37 would have required decompression on an 80/360 Standard Air Schedule requiring 279 minutes of decompression stops. Profile #38 would have required decompression on a 100/360 Standard Air schedule which has 415 min of decompression stops.

DISCUSSION

The main purpose of this study was to see if the computer algorithm which had previously been developed and tested for constant 0.7 ATA PO_2 in N_2 diving (the EL-MK 15/16 DCM) could be extended to air diving and furthermore could handle gas switches between gases of different oxygen partial pressures. When originally developed, the U.S. Navy Standard Air Tables were computed assuming that oxygen has no effect on the development of DCS but that only the inert gas partial pressure was important (9). However, in a series of experiments using goats, Eaton and Hempelman (10) showed that replacing nitrogen with oxygen did not change the DCS threshold as much as one would expect if oxygen played no role in causing DCS. Therefore, it must be concluded from Eaton and Hempelman's results that some portion of inspired oxygen tension does play a role in DCS. Conceptually what makes oxygen different from inert gases is its high blood (hemoglobin) solubility which is not linearly related to blood partial pressure and the fact that it is metabolized by tissue. Depending on the tissue metabolic rate, an increase in arterial oxygen tension may result in an insignificant rise in venous oxygen tension for areas of high metabolism or substantial rises for areas with low metabolism. In modifying the EL-MK 15/16 DCM it was decided to base the ascent criteria on total tissue gas tension and develop a scheme for calculating changes in tissue oxygen tension as a function of inspired oxygen tension. It was also assumed that venous and tissue gas tensions were the same. The mathematical representation of the hemoglobin dissociation curve described earlier in this report provides a method of computing venous from arterial oxygen tension but one must specify a metabolic rate for each tissue of interest. This is most conveniently done by specifying the steady state difference between arterial and venous oxygen concentration (CAVO2). The problem then becomes choosing appropriate values for CAVO2.

Development of Initial Ascent Criteria (VVAL22)

If one takes the EL-MK 15/16 DCM using VVAL18 as used to compute the Constant 0.7 ATA PO_2 in N_2 Decompression Table and computes schedules using a constant 21% oxygen fraction (air) one obtains schedules which are three to five times longer than current USN Standard Air Schedules (Table E-1, Appendix E). On the other end of the spectrum, Vann (11) has calculated and tested two decompression schedules using an N_2-O_2 mix of a constant 1.4 ATA PO_2 which was reduced to 1.3 ATA and the last decompression stop which was taken at 20 FSW. Vann's model predicted a 100 FSW/60 min schedule with 90 min of decompression stops breathing a constant 0.7 ATA PO_2 and only 20 min of stops with a 1.4/1.3 ATA PO_2. For a 150/60 schedule the decompression stop time was reduced from 195 min to 105 min. Selected VVAL18 schedules for 0.7 ATA PO_2 are shown in Table E-2 of Appendix E and it will be noted that the 100/60 schedule is 27 min shorter than Vann's 0.7 ATA PO_2 schedules but the 150/60 is 7 min longer. If 1.4 ATA PO_2 schedules are computed using the EL-MK 15/16 DCM and VVAL18, the decompression stop times are reduced to 10 min for the 100/60 schedule, much shorter than predicted by Vann. Vann had tested his 1.4/1.3 ATA schedules on 20 man-dives each without DCS and based on this limited experience it was decided that the EL-MK 15/16 DCM should initially be modified to compute 1.4 ATA PO_2 schedules with total decompression times close to Vann's. In computing the VVAL18 1.4 ATA schedules the PO_2 was assumed to be 1.4 ATA during the last stop which was taken at 20 FSW (1.61 ATA). Vann reduced the PO_2 to 1.3 ATA at 20 FSW for technical reasons, which makes his schedules slightly longer than they would have to be if 1.4 ATA was breathed throughout. This excess time provided a bit of "slop" when fitting the EL-MK 15/16 DCM to Vann's data.

In original the EL-MK 15/16 DCM the tissue offgassing rate is linear and goverened by the equation:

$$(5) \qquad DPDT = SDR \cdot K \cdot (P_{A_{N_2}} - P_{V_{N_2}})$$

$$= SDR \cdot K \cdot (P_{VO_2} + P_{V_{CO_2}} - P_{A_{CO_2}} - P_{A_{O_2}} - PBOVP)$$

where:

$P_{V_{N_2}}$ = Venous nitrogen tension (FSW)[5]

$P_{A_{N_2}}$ = Arterial nitrogen tension (FSW)

$P_{V_{O2}} + P_{V_{CO_2}} - PA_{CO_2}$ = 2.8 FSW (Table 9)

SDR = Saturation Desaturation Ratio

K = exponential time constant

$P_{A_{O_2}}$ = alveolar PO_2 (FSW)

PBOVP = Tissue specific gas phase overpressure (FSW)

(See reference 1 for details)

If one examines the ratio of offgassing rates (DPDT) for different PO_2 levels for a given tissue, one will see that the ratio approaches 1.0 as PBOVP increases. That is, by specifying a PBOVP greater than 0.0, the percentage increase or decrease in DPDT as the PAO_2 is raised or lowered from a reference value will decrease. If a reference PO_2 level of 0.7 ATA is chosen, the SDR can be decreased as PBOVP is increased so that DPDT calculated at the 0.7 ATA reference value doesn't change. Unfortunately, decompression schedules will change slightly because as PBOVP increases, the tissue tension at which the offgassing rate slows from linear to exponential changes (1). When PBOVP was increased from 0.0 to 10 FSW and the SDR reduced from 1.0 to 0.67 for all tissues, DPDT at 0.7 ATA (23.1 FSW) PO_2 remains unchanged. The 100/60 decompression schedule at 0.7 ATA using the EL-MK 15/16 DCM and VVAL18 (maximum tissue tensions) was unchanged but the 150/60 schedule TDT increased to 221 min (14 min increase in 20 FSW stop and 15 min increase at 10 FSW). When used to compute air schedules, the above modifications to the SDR and PBOVP of VVAL18 reduced the 100/60 decompression schedule TDT from 158:40 to 96:40 and the 150/60 TDT from 383:30 to 297:30. While these air schedules are still 2.5 and 2.6 times longer than USN Standard Air Schedules, they are not much longer than other air schedules which have been proposed, especially the RNPL schedules (12).

The reduction in calculated decompression times using VVAL18 and modifying the values for SDR and PBOVP was most welcome. However, when schedules using a 1.4 ATA PO_2 were computed, the TDT for the 100/60 schedule was increased only 2 min to 12:40 and for the 150/60 increased by 17 min to 76:30. These increases were not felt to be close enough to Vann's predictions so it was decided to investigate other methods of modifying the decompression model to somewhat blunt the effect of the large change in TDT with change in inspired PO_2 levels. The initial attempt at this was the EL-MK 15/16 DCM-I in which a slight change was made to the way the alveolar PO_2 was computed (Table 3) and in which values for other Blood Parameters were changed (Table 9, VVAL 22-28). The change in the way alveolar PO_2 was computed prevented computed arterial nitrogen tensions from becoming negative when 100% O_2 was breathed. The arterial CO_2 level was assumed to be 40 mmHg which rounded off to 1.7 FSW and water vapor pressure at body temperature 47 mmHg which rounded off to 2.0 FSW. The venous carbon dioxide tension will vary as venous oxygen tension changes and was calculated to change from 41 to 45 mmHg over a venous oxygen tension rage of 50 to 75 mmHg. This change was small and to reduce the complexity of the model a mean value for venous CO_2 tension of 43 mmHg (1.87 FSW) was chosen which was assumed constant for all venous oxygen tensions. The value of AMBA02 was supposed to represent the difference between alveolar and arterial oxygen levels and was chosen as the calculated 57 mmHg (2.46 FSW) difference between arterial and alveolar O_2 at 0.7 ATA inspired oxygen assuming a 4% shunt in the lungs. This physiological rationalization was soon dispensed with by assuming that arterial and alveolar nitrogen tensions were the same resulting in not having to calculate the arterial oxygen tension for the EL-MK 15/16 DCM-I. The values for PBOVP were kept at 10.0 FSW because of the desirable effect this had on decreasing the magnitude of change in TDT with changes in inspired PO_2.

The PVO_2 value of 2.8 FSW (65 mmHg) for VVAL22-29 represents the assumed value for a tissue with a 2.39 Vol. % a-v extraction and an inspired PO_2 of 0.7 ATA. If PAO_2 is computed as shown in the DCM-I column of Table 3 and other values in equation (5) are taken from the VVAL22-28 row of Table 9, it can be shown that an SDR of 0.72 is needed to keep the calculated offgassing rates (DPDT) for a constant 0.7 ATA PO_2 the same as in the original EL-MK 15/16 DCM model. Schedules computed for constant 0.7 ATA PO_2 using the EL-MK 15/16 DCM-I with VVAL18 but with the VVAL22-28 Blood Parameters (Table 9) and SDR values of 0.72 decreased the TDT for the 100/60 schedule by 1 min and increased the TDT for the 150/60 by 8 min compared to VVAL18 Tables computed using the original model and Blood Parameters. When a constant 1.4 ATA PO_2 was used, it was assumed that the increase in venous oxygen tension would be 120 mmHg (assuming the tissue extracted 2.39 Vol. % of O_2) or 5.54 FSW. Schedules computed using the DCM-I, VVAL18, and VVAL22-28 Blood Parameters assuming venous PO_2 of 5.54 FSW gave a TDT for the 100/60 of 23:40 and a TDT for the 150/60 of 109:30, very close to the 20:40 and 105:30 times of Vann's schedules.

The DCM-I model was easily adjusted to compensate for the two different constant PO_2 values of 0.7 ATA and 1.4 ATA simply by adjusting the PVO_2 Blood Parameters. If air is used as a breathing gas, the PVO_2 value will be different at each depth so simply adjusting PVO_2 will not work. To compute air schdules, the actual MPTT values were adjusted at each depth as previously described in the Ascent Criteria section. VVAL18 was adjusted in this manner and when combined with the Blood Parameters in the VVAL22-28 row of Table 9, resulted in the new MPTT Table VVAL22 (Appendix D). VVAL22 was then used with the EL-MK 15/16 DCM to compute a set of air decompression schedules. The resulting air schedules are given in Table E-1 of Appendix E. It was VVAL22 and the EL-MK 15/16 DCM-I which was used as the initial method of air table calculation. All MPTT's are given in Appendix D.

To summarize, the original EL-MK 15/16 DCM using VVAL18 was judged unsatisfactory because computed air decompression schedules appeared too long while schedules using a constant 1.4 ATA PO_2 appeared too much shorter than schedules which had been previously tested. In order to shorten computed air tables and lengthen the 1.4 ATA PO_2 tables the PBOVP was increased from 0.0 to 10 FSW. Since it was desirable to keep 0.7 ATA PO_2 Tables as close as possible to those which were previously tested the offgassing rate (DPDT) had to be kept the same and the SDR was decreased from 1.0 to 0.67 to compensate for the change in PBOVP. The result of these adjustments was that air schedule TDT's were reduced but 1.4 ATA PO_2 schedules were still too short. The Decompression Model was then changed to the EL-MK 15/16 DCM-I and MPTT values were adjusted to compensate for changes in venous oxygen tension as inspired tension varied from 0.7 ATA. When breathing air, the MPTT adjustment was depth dependent reflecting the different inspired oxygen tensions at various depths. The resulting MPTT Table was VVAL22 which was the first one used for air diving in this study.

EL-MK 15/16 DCM-I Testing (VVAL22-29)

The initial testing of the EL-MK 15/16 DCM-I with air using VVAL22 gave the impression that the 60/180 and 100/60 schedules were safe but that the deeper 150/60 schedule was not long enough (Table 4). At this point it was decided to dive some USN Standard Air schedules to see what the DCS incidence for these schedules under controlled conditions was. Since the dives were considered cold, hard-working dives the standard USN practice of using the next longer bottom time schedule was implemented. The 100/70 Standard Air Schedule proved DCS-free in 29 man-dives when used to decompress from 100 FSW after a 60 min bottom time. The initial attempt at a 60/180 dive on August 30 was aborted early for technical reasons and decompressed after 100 min on a 60/100 standard air schedule, which was DCS-free in 9 man-dives. Retesting of the 150/60 schedule using VVAL22 confirmed that this schedule, although over 2.5 times longer than the Standard Air Schedule was too short.

Decompression from 60 FSW after 180 min using the 60/200 Standard Air Schedule produced 3 cases of DCS in 10 man-dives. At this point, a return was made to decompression schedules computed by the EL-MK 15/16 DCM-I using the newly computed VVAL25. VVAL25 used the same MPTT values as VVAL22 but the SDR's were increases to 1.0 which put the TDT for a 60/180 dive about halfway between that predicted by the 60/200 Standard Air Schedule and the previously tested VVAL22 schedule. This gave 4 cases of DCS in 10 man-dives and it was decided that the previously tested 60/180 VVAL22 schedule was not too short after all.

While the 60/200 Standard Air Schedule was a total failure in decompressing from a 60/180 dive, 9 divers were decompressed from 100 FSW after 60 min on a 100/60 Standard Air Schedule. This incredible disparity between the safety of the 100/70 and 100/60 Standard Air Tables and the 60/200 Standard Air Table prompted testing of an intermediate schedule. The 120/70 Standard Air Schedule was used to decompress from 120/60 dive and produced only 1 mild knee pain in 20 man-dives.

It is interesting to note that Berghage (7) in a review of fleet diving from 1971-1978 reported that the 100/60 Standard Air Schedule had the highest incidence of DCS according to U.S. Navy dive records, 5 cases in 104 man-dives. This would predict a 10% incidence assuming a binomial distribution. There were too few dives done using the 100/60 schedule in this study to make a valid comparison. Only two dives were reported by Berghage using the 60/180 schedule (which were DCS-free). As a matter of fact, Berghage reported that only only 35 man-dives were done at 60 FSW with bottom times greater than 70 min. In the 120 FSW range, only 11 dives were reported for the 60 min bottom time (with no DCS) while 2347 were done with shorter bottom times. Clearly, except for the 100/60 schedule, fleet experience for long bottom times at 60 and 120 FSW is minimal.

At this point, it was felt that safe air schedules for the 60/180, 100/60 and 120/60 dives were at hand. At 150 FSW, lengthening of the decompression schedule for the 60 min bottom time would have required an impractical amount of time in the water, so it was decided to try decompression after shortening the bottom time. By changing the VVAL25 SDR's only, VVAL26 was created to put the TDT for a 60/180 dive back to 153 min and to make the TDT for a 150/40 dive about the same as for a 150/50 Standard Air Schedule (88:30). The resultant 150/40 schedule had a TDT of 85:30 which made it only 1.4 times longer than the Standard Air 150/40 schedule. This rather mild increase in TDT was thought reasonable based on the success of the 120/70 schedule and the much increased no-decompression limit at 150 FSW which had been successfully tested. The resulting 2 cases of DCS in 29 man-dives was an improvement over the 150/60 incidence and both cases of DCS were mild.

Based on the experience of Phase 1A, VVAL28 was created which attempted to keep the TDT for a 100/60 schedule close to that of the 100/70 Standard Air Schedule, lengthen the 60/180 to a TDT slightly longer than the VVAL22 schedule and lengthen the 150/40 schedule compared to VVAL26. The surfacing MPTT for the 240 min tissue was chosen as 44.26 which would allow surfacing directly from 25 FSW after saturation on air. Bell et al (13) have in fact shown that the no-decompression saturation depth on air is somewhere between 23 and 26 FSW. The changes made to VVAL26 to get VVAL28 were only in the MPTT's for the 120-200 min tissues because the 10 FSW stops for both the 60/180 and 150/60 schedules were controlled by tissues in that range. The main casualty of VVAL28 was the 120/60 schedule which acquired a TDT of 147 min when it appeared that a Standard Air Decompression 120/70 schedule with a TDT of 89 min would suffice. Initial testing of VVAL28 looked very promising with 18 DCS-free dives on the previously unsafe 150/40 and 19 DCS-free dives on a new 100/90 schedule. When a 190/40 dive was attempted there were 2 DCS in 10 man-dives but restricting the bottom time to 30 min at that depth resulted in 19 DCS-free dives. VVAL28 handled a 6 hour 50 FSW dive without DCS in 20 man-dives and produced 18 DCS-free dives for 60/120 schedules.

Attempts to extend the 60 min bottom time at 120 FSW using VVAL28 to 80 or 70 min were unsuccessful giving rise to 2 cases of DCS on each of the 10 man-dives on these schedules. When a 60 min bottom time at 120 FSW was repeated, there was a single case of mild DCS in 29 man-dives showing that the 147 min TDT was not over conservative.

By the end of Phase 1, VVAL28 had been modified considerably from the starting MPTT, VVAL22, and it was desirable to see if 0.7 ATA schedules would prove safe. VVAL28 was modified for a constant 0.7 ATA PO_2 to VVAL29 as previously described (see Ascent Criteria). VVAL29 produced no DCS on significantly shortened 100/60 and 150/30 schedules (compared to VVAL18). This success lead to an attempt to increase the 150 FSW bottom time to 60 min which produced 2 cases of DCS in 9 man-dives. Even backing off to a 40 min bottom time at 150 FSW produced 2 cases of DCS in 26 man-dives.

At this point it appeared VVAL28 would compute air decompression schedules with a low risk of DCS within the following maximum depth/time limits: 50/240; 60/180, 100/90; 120/60; 150/30; and 190/30. Also, it appeared to allow some shortening of constant 0.7 ATA P02 schedules within previously tested depth/time limits. These restrictions were acceptable from an operation standpoint so further time was not spent trying to extend them. Rather, the models ability to handle repetitive dives was tested.

At the beginning of Phase 2, VVAL28 was tested on some repetitive dives also. VVAL28 initially looked adequate on the 150 FSW air decompression repetitive Profile #36 but when used on the 100 FSW profile it proved totally inadequate giving rise to 3 cases of DCS in 9 man-dives.

EL-MK 15/16 DCM-II Testing (VVAL50-59)

At this point a new modification of the decompression model was brought on line, the EL-MK 15/16 DCM-II. This new model now incorporated equations for calculating venous oxygen tension as a function of arterial so that MPTT adjustments for various PO_2 levels would not have to be done. VVAL50 was designed to compute air schedules close to VVAL28 and constant 0.7 ATA PO_2 schedules close to VVAL29. Table E-1 of Appendix E shows that VVAL50 air tables were changed only slightly from VVAL28 tables. The 0.7 ATA constant PO_2 schedules were almost identical to VVAL29 with the maximum increase in TDT being 1 min. When schedules breathing 1.4 ATA constant PO_2 were calculated, the 100/60 schedule TDT was 22:40 and the 150/60 was 126:30, both times comparing favorably with the 20:40 and 109:30 schedules tested by Vann. So a single model was now at hand which would reasonably fit schedules which were tested on air, a 0.7 ATA constant PO_2 and 1.4 ATA constant PO_2.

VVAL50 was short lived producing 2 cases of DCS on 9 man-dives on the 150 FSW repetitive dives. Up to now, the gas phase overpressure, PBOVP, had been kept constant at 10 FSW for all tissues and changes in decompression schedules had been brought about by changing the surfacing MPTT's and the SDR's. By slowing offgassing through a decrease in SDR values, the offgassing rate change is the same at all inspired PO_2 values. However, by manipulating the PBOVP, offgassing rates will change more at lower PO_2 values than at higher values. Both SDR's and PBOVP values in VVAL50 were changed to get VVAL52 with the specific intent of having a greater slowing of offgassing shallow, especially at the surface during the surface interval. The TDT for the second dive of Profile 35 was increased by 57 min and for the first dive only 3 min with VVAL52. This made profile 35 too long to be tested during a normal work day so the bottom time for second dive was cut to 40 min resulting in Profile 34. The single case of DCS in 8 man-dives using VVAL52 on Profile 34 was a mild knee pain but was atypical in that it was first noted at 70 FSW during ascent. Considering the mildness of the DCS and the length of the decompression schedule it was decided to persist with VVAL52 a while longer.

A series of dives breathing air at depth and 0.7 ATA PO_2 during decompression were tested using VVAL52. A total of 87 min of decompression time was taken off the 100/90 schedule compared to the previously tested VVAL28 schedule using air. No DCS occurred in 19 man-dives. More surprising was the 19 DCS-free dives on a 150/40 schedule, one which had produced DCS both using a constant 0.7 ATA PO_2 and air.

It was the results of the next dive tested, a 100 FSW no-decompression repetitive dive which caused VVAL52 to be modified. Not only did 2 cases of DCS occur in 10 man-dives but one occurred after the first dive, a no-decompression limit having previously produced no DCS in 20 man-dives. VVAL53 was an intermediate MPTT Table used only on the 80/120 schedule. It was rapidly modified to VVAL54 which had modified SDR's for the 5-40 min tissue and different MPTT's for the 40 and 120 min tissues compared to VVAL52. These adjustments were designed to decrease the 100/60 TDT toward that for a Standard Air 100/70 (57:40) while decreasing the no-decompression limit for the second 100 FSW dive on Profile #30. When retested, Profile #30 using VVAL54 produced 3 cases of DCS after the first 100 FSW no-decompression dive. This rash of DCS caused consideration of diver fatigue as a possible cause of increased DCS incidence. VVAL55 changed the MPTT's for the 40 and 80 min tissue as well as the PBOVP values and increased the 40 FSW SDR to 0.96. This reduced the no-decompression limit for the first 100 FSW dive to 26.5 min, close to the 25 min in the Standard Air Tables while the no-decompression limit for the second dive increased. This change allowed 16 DCS free dives on Profile #30.

VVAL56 was another transient MPTT Table replaced by VVAL58 after only a single dive. VVAL58 was designed to maintain the best fit to previously tested profiles while decreasing the second no-decompression time for the second 100 FSW dive on Profile #30 which dropped by well over 2 min compared to VVAL55. The 100 FSW repetitive dive profile was extended to three dives and the two cases of DCS which arose occurred after the last dive. The 80 FSW repetitive dive profiles appeared reasonably safe overall with only 2 mild cases of DCS both occurring after the second dive. VVAL58 was eventually modified to VVAL59 based mainly on the results of the multiple level dives involving switches between air and constant 0.7 ATA PO_2 breathing media. This change involved only the SDR for the 40 and 120 min tissue which served to lengthen the TDT for the final decompression on Profiles #37 and #38.

Overall, modification of the decompression model was influenced by two forces. One was not to lengthen schedules which were felt to be safe by too much, and the other was to decrease the rate of offgassing at the surface so that repetitive dive no-decompression limits would be shorter. It must be remembered that the Standard Air Repetitive Dive Tables are computed from a different set of premises than the Standard Air Tables. Details of the way the Standard Air Repetitive Dive Tables were calculated are given elesewhere (14), but in summary all repetitive dives assume that the 120 min tissue will always control the second dive. If repetitive dives had been computed using exactly the same premises as used for the Standard Air Single Dive Tables the Residual Nitrogen Times for the second dive would be much shorter than arrived at using current USN procedures. The goal in this study was to use the same model for the entire dive. This resulted in decompression times for repetitive dives involving decompression to increase markedly but it also allowed no-decompression limits for repetitive dives to increase. As testing progressed, it was just not possible to adjust the no-decompression repetitive dive limits without lengthening profiles which already appeared safe. Part of the reason for this may have been the way the model was adjusted. For example, one could have individually adjusted the arterial-venous oxygen extraction and venous CO_2 levels for each tissue. Time was simply not available to test this. Also, the effect of individual variation must be taken into account. Certainly some schedules may have proved safer if more dives could have been done on them.

Decompression Sickness Symptoms

Appendix C shows the diving intensity for all divers in this study. Generally, divers had at least 2 days off between dives. In all there were 49 cases of DCS in 39 different divers and 2 in tenders. A total of 9 divers had DCS more than one time, Divers 49 and 71 having had DCS three times, and Divers 5, 13, 55, 82, 104, 115 and 122 having DCS two times. Diver 122 had one of his cases of DCS while serving as a tender, the other tender being subject 118.

There were only 7 cases of Type 2 DCS which occurred in Divers 24, 40, 55, 65, 68, 104 and 122. The incidence of Type 2 DCS was 14.3%. This is comparable to the 17% incidence of Type 2 symptoms in previous N_2O_2 dive series (1, 8) and less than half that of the 37% incidence encountered testing HeO_2 decompression tables (15). Of all Type 2 cases encountered, all but 3 were mild changes in peripheral sensation or mild decreases in strength. The 3 exceptions were all severe cerebral symptoms. Diver 40 suffered memory lapses and marked weakness and sensory changes on the right side. He was followed closely with a battery of neuropsychological tests and required 3 Treatment Table 6's for complete relief. Diver 55 suffered an attack of nausea and lower extremity weakness which responded immediately to compression to 60 FSW. Diver 122 had a mild Type 2 symptoms as a subject on a 230/70 dive consisting of decreased sensation over the right knee but suffered a bout of lightheadedness and profound right sided weakness as a tender on Profile #31. This individual was the only one to have suffered Type 2 DCS more than once.

All but 6 cases of Type 1 DCS were straightforward which responded initially to a Treatment Table 5 or 6. Diver 110 suffered a particularly resistant bout of shoulder pain which required multiple treatments. Complete resolution of symptoms took 3 months. Four months after the incident this diver made a 60 FSW experimental air saturation dive without incident. It is interesting to note that this diver was the first and only female to participate in these dive series. Diver 13 had suffered DCS twice, both Type 2 symptoms. On the second occurrence he had a recurrence of symptoms during decompression which required recompression to 60 FSW. Diver 17 was initially treated for knee pain with complete relief on a Treatment Table 5 but 18 hrs later reported shoulder pain. He showed no change in this pain after 20 min at 60 FSW and it was thought this was not DCS so he was brought to the surface. The pain was mild but persisted over the next 3 days and was present just before he made a 150/40 0.7 ATA constant PO_2 dive. The pain disappeared at 150 FSW and never returned so a diagnosis of residual DCS was made retrospectively. Divers 63, 33 and 104 all suffered Type 1 symptoms after multiple level dives and all had recurrences during treatment requiring recompression.

There was no particular physical characteristic which set the divers who suffered DCS apart from those who didn't (Appendix A). Also, there was no particular set of physical characteristics distinguishing divers who suffered Type 2 symptoms are those who suffered DCS more than once from other divers. The time of onset of symptoms ranged from immediately post dive up to 40 and 72 hrs post dive and there was no particular pattern to the symptoms except to say shoulder and knee pain predominated.

Overall, all but a single case of DCS occurring on this series responded completely to Standard USN Oxygen Treatment Tables and Procedures. The only exception was Diver 110 who received non-standard treatments after conventional treatments had only provided partial relief.

Final Decompression Model and Tables

VVAL59 using the EL-MK 15/16 DCM-II was the final result of testing. A complete set of Air Tables is presented in Appendix F. The same depth/bottom time combinations in the current USN Air Schedules were used and the limit lines show the division between Standard Air Schedules and Exceptional Exposure Schedules as currently defined (6). The no-decompression limits down to 110 FSW were revised to be close to those already published in the Standard Air Tables (Table 10). This was done in spite of longer limits having proved safe but the reduction was considered prudent in light of the rash of DCS after the first 100 FSW no-decompression dives during Phase 2. As one moves away from the no-decompression limits, the decompression times get considerably longer than current Standard Air Schedules allow. In trying to compensate for the DCS incidence which occurred on repetitive dives, final bounce dive schedules became longer than some shown to be safe during testing. The 60/180 schedule gained an additional 55 min over the VVAL22 schedule and the 100/60 gained 17 min over the 100/70 Standard Air Schedule.

Schedules which were not safe but could not be retested gained considerable amounts of time. The 150/60 picked up 67 min, a 24% increase over the tested VVAL22 schedule and the 190/40 picked up 81 min, a 35% increase over the tested VVAL28 schedule.

In computing 0.7 ATA constant PO_2 schedules, the 100/60 and 150/30 profiles which had proven safe with substantial reduction in decompression time compared to the previously published VVAL18 decompression tables gained back some time but were still shorter than VVAL18 tables. The 150/40 and 150/60 schedules, which had a high DCS incidence gained 32 and 55 min respectively compared to the VVAL29 schedules which were tested. Also, these schedules are longer than VVAL18 schedules. A complete set of 0.7 ATA constant PO_2 in N_2 schedule using VVAL59 is given in Appendix G.

When VVAL59 is used to compute constant 1.4 ATA PO_2 schedules, the TDT for the 100/60 schedule is 20:40 and for the 150/60 135:20. The 100/60 TDT is the same as the 1.4 ATA profile tested by Vann, but the 150/60 is 30 min longer, a result of compromises made in modifying the decompression model based on test results.

Table 11 shows the expected incidence of DCS for the various aspects of the study. The overall expected incidence on air bounce dives was 7.1%. However, by restricting the maximum depth/time limits to the values shown, the expected incidence falls to 3.2%. In previous testing of the constant 0.7 ATA O_2 in N_2 schedules, the final test results showed 393 dives fell within the final model which gave rise to 8 cases of DCS, giving an expected incidence of 3.5%. Based on this comparison, the expected incidence of the tables resulting from these two studies is about the same.

Testing of the current U.S. Navy Standard Air Tables involved 688 man-dives resulting in 47 cases of DCS (16,17) while the present study involved 837 man-dives and 49 cases of DCS. In numbers these studies are comparable but not in methods. In testing of Standard Air Tables, only a few dives were done on as many schedules as possible including some 47 different repetitive dive profiles. Once profiles were found safe they were generally not retested. In addition, because of a high incidence of DCS some individual decompression tables had to be empirically modified. The intent of the present study was to develop a single computer algorithm which would compute decompression schedules for complex profiles as well as compute a set of conventional tables. In this regard, testing involved areas perceived to have the highest decompression risk and it is the overall incidence of DCS which became important, not the incidence on specific tables. In looking at Table 11, however, the repetitive dives stand out as having the highest incidence of DCS of all the groups tested. Even excluding Profile #30 using VVAL52 and VVAL54 which proved safe when lengthened does little to lower the expected incidence. Excluding these profiles drops the expected incidence considerably to 7.2%. However, Profiles 34, 35, and 36 were much longer than Standard Air Schedules and one would expect their DCS incidence to be lower than Standard Air Schedules.

The remarkably low incidence of DCS when 0.7 ATA PO_2 was breathed during decompression from air dives shows that the EL-MK 15/16 DCM-II sufficiently compensate for changes in PO_2 level on bounce dives. However, the ability of the model to handle the long multiple level dives remain uncertain because of lack of previous experience in this area. The DCS incidence observed in this study of 4 cases in 38 man-dives is certainly high but the symptoms were all mild. Certainly, more experience in this area is required.

The final VVAL59 Decompression Tables are comparable in TDT to the RNPL Tables for long dives, but have much longer no-decompression times (12). It is interesting that while the RNPL Tables proved very safe in testing, they were rejected by the Royal Navy fleet operators because the no-decompression times were shorter than those known to be safe. Also, decompression times were longer for dives in the current Royal Navy Tables known to be safe or only producing a slight incidence of DCS (18). However, Leitch and Barnard report that the current Royal Navy Tables have an unacceptable risk of about 6% DCS for depths 140 FSW and deeper for durations exceeding 15 min. Certainly the results of the present dive series would indicate that for long shallow dives or deep dives, the current USN Standard Air tables would have an unacceptable incidence of DCS. The EL-MK 15/16 DCM-II does fit current no-decompression limits nicely and does not increase TDT too much within the depth/time domain of most USN air diving. Certainly based on the high incidence of DCS on the 60/180, 150/60, and 190/40 schedules, one must conclude that the increases in the lengths of the decompression schedules are fully justified and not over-conservative.

In other areas of this study results are less conclusive but indicate that the EL-MK 15/16 DCM-II predictions of shortening decompressions for constant 0.7 ATA PO_2 in N_2 dives are reasonable. Indications are that no-decompression times for repetitive dives can be increased compared to current USN procedure but that further testing will be required. However, VVAL59, did shorten repetitive dive no-decompression limits compared to those actually tested so a decreased incidence of DCS would be expected. Certainly, when DCS did occur on repetitive dives in this study it tended to be mild. However, the DCS which occurred in two tenders who were in dry warm chambers and 7 FSW shallower than diver subjects suggests that testing of no-decompression limits in warm water should be done to verify that this will not shorten no-decompression times.

Decompression Model Limitations

The EL-MK 15/16 DCM-II retains many of the characteristics of previous Neo-Haldanian Models. The most obvious is the retention of 9 perfusion limited tissues. However, the assumption of gas phase formation and consequent linear offgassing (vice exponential) is unique. Also, the fact that oxygen is treated the same as all other dissolved gases and contributes to DCS based on its partial pressure is also unique. In developing the EL-MK 15/16 DCM-II the oxygen extraction differences and venous CO_2 tensions for all tissues were assumed to be the same, this being done for simplicity. There is no reason to expect, however, that this need remain so and making these values tissue dependent may provide a better fit of the model to the available data. Also, changes in inspired oxygen tension are assumed to be instantaneously reflected in arterial and venous levels, a condition which causes switches to 100% O_2 to cause violations of the ascent criteria in certain instances. The answer to this problem remains to be worked out.

On the positive side, the EL-MK 15/16 DCM-II does provide a reasonable fit to existing data on tested dives of widely varying PO_2 levels. The 240 min MPTT's were also adjusted to predict a reason^ble decompression from saturation on air at 60 FSW. The model allows an upward excursion from 60 FSW to 30 FSW and predicts stops of 7 hrs 30 min at 30 FSW, 10 hrs 30 min at 20 FSW and 12 hrs 30 min at 10 FSW for a TDT of 30 hrs 40 min. A total of 9 man-dives were done on this schedule without DCS. Schedules which were previously tested with decompression times less than 30 hours produced DCS, so the 30 hr schedule is not over conservative (19). Overall the EL-MK 15/16 DCM-II remains the most flexible model developed by the USN to date. Although further testing is required in the repetitive dive area this model would probably have a lower overall incidence of DCS than current procedures and would suffice for computing real time decompression schedules for N_2O_2 diving for any PO_2 level.

In examining the air decompression tables in Appendix F, some decompression times are drastically increased compared to current USN Air Tables. This is especially true of the Exceptional Exposure Tables. As an example, the current 60 FSW/720 Exceptional Exposure Air Schedule calls for 266 min of TDT, while the schedule in Appendix F calls for 1496 min. Considering that the saturation decompression schedule discussed above required 1840 min of decompression, 1496 min for a 12 hr bottom time is not unreasonable. The Exceptional Exposure Tables were not formally tested but experience from this study would indicate that the DCS incidence of currently published schedules would be high. Whether or not the increases in TDT predicted by the EL-MK 15/16 DCM-II model outside of the tested depth/time domain are necessary remains to be seen, but the impression from this study is that they are justified.

CONCLUSIONS

1. Tissue oxygen tension plays a contributing factor in the development of DCS and must be taken into account.

2. Current USN Standard Air No-Decompression Limits are safe.

3. Decompression Times for dives with long bottom times need to be longer than allowed in current USN Standard Air Tables and the percentage increase in decompression time is greater as bottom time increases.

4. When doing no-decompression repetitive diving, some extension of repetitive, some extension of repetitive dive no-decompression times beyond those for USN Standard Air Tables Repetitive dives are possible.

5. The EL-MK 15/16 DCM-II using VVAL59 should undergo further testing and modification on no-decompression repetitive diving.

6. No-decompression limits for air diving should be tested in warm water.

7. The EL-MK 15/16 DCM-II using VVAL59 could be used for real time decompression schedule calculation for air or air/0.7 ATA O_2-N_2 diving with an acceptable risk of decompression sickness which should be less than using current USN Standard Air Tables.

FOOTNOTES

1 Some dives had bottom times too short for each team member to do a full 6-min exercise run. In these cases, each team member exercised for one-half of the available bottom time.

2 NEDU Report 1-84 (1) mistakenly reported divers exercising 10 min at 50 watts. In fact, the exercise protocol for the N_2O_2 dives (1) was exactly the same as done in this study.

3 See page 166 of West, J.B. Respiration Physiology, Williams and Wilkins, Baltimore, MD, 1974.

4 The oxygen sensors in the MK 15 UBA measure absolute oxygen partial pressure. Since the MK 15 breathing loop rapidly saturates with water vapor the maximum oxygen partial pressure must be $PAMB-P_{H_2O}$.

5 In this report gas tensions are reported in feet of sea water (FSW), atmospheres (ATA), or mmHg which are related as follows:

1 ATA = 33 FSW = 760 mmHg

6 33 FSW = 760 mmHg = 1 ATA.

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APPENDIX A

DIVER PHYSICAL CHARACTERISTICS

DIVER PHYSICAL CHARACTERISTICS

DVR NO.	PHASE @	AGE (YRS)	HT (IN)	WGT (LBS)	SKINFOLDS (mm) TRI	SS	SI	%FAT (NOTE 1)
1	3	31	64	167	9.0	19.0	13.3	20.8
2*	2	23	71	179	7.5	11.0	4.0	10.9
3	3	23	69	162	19.3	8.1	5.8	15.4
4	1	30	68	153	6.0	13.0	3.6	14.5
5*	2	25	73	197	19.0	14.6	10.0	18.6
6	1	23	67	162	11.1	9.5	4.5	12.1
7*	3	24	72	184	4.6	9.6	4.3	8.6
8	0,1	22	70	180	9.6	13.8	3.5	12.9
9	1	30	68	157	14.0	13.5	2.8	17.6
10	2	24	71	173	9.0	9.3	5.3	11.4
11	2	25	70	177	5.0	7.0	3.0	6.2
12	2	21	72	192	9.3	8.0	4.0	10.2
13*	0,1	35	76	195	12.1	9.5	3.5	15.6
14*	2	26	72	186	11.6	11.6	5.3	13.6
15	3	25	72	176	5.0	7.0	3.3	6.5
16	0	28	69	164	11.6	11.6	5.6	13.7
17*	2	23	72	196	11.0	12.3	6.6	14.2
18	0	46	68	155	4.5	7.5	3.0	10.0
19	3	25	70	151	5.0	11.5	3.5	9.5
20	3	20	70	179	8.0	8.1	3.0	9.0
21	0,1	24	72	175	12.5	10.5	5.8	13.7
22	0,1	32	72	200	13.0	16.0	9.0	19.9
23	0	37	69	151	6.1	15.5	10.3	18.1
24*	0	37	70	170	13.0	13.6	5.6	18.2
25	0,1	24	68	145	3.0	7.0	2.5	4.2
26*	1	27	73	235	22.6	25.6	8.0	21.6
27*	2	21	67	159	4.0	12.8	4.3	10.1
28	0	31	72	172	15.6	9.3	4.3	17.2
29	0,3	33	70	169	12.0	19.3	5.6	19.6
30	3	32	71	165	6.3	9.0	2.0	11.8
31	0,1,2,3	45	69	162	7.6	12.3	5.3	17.0
32*	0,1,2	30	71	146	10.6	8.8	4.6	15.1
33*	1,3	22	73	205	19.3	15.0	6.0	17.7
34	1	34	67	160	6.6	8.3	4.0	12.7
35	3	23	72	176	4.5	12.0	5.0	10.3
36	3	21	72	190	4.0	10.6	2.3	7.6
37*	0,1,2	27	71	194	10.0	13.3	6.8	14.2
38	0,3	24	72	152	6.0	9.5	3.8	9.1
39	2	20	72	160	5.8	10.1	5.5	10.3
40*	0,1	40	70	185	8.6	14.1	5.3	18.4
41	0	29	67	154	7.3	15.6	5.0	13.4
42*	0,1	27	68	152	12.5	12.8	4.0	13.9
43	1	29	72	208	6.8	19.5	12.3	17.2
44	2	20	71	178	10.3	14.3	5.0	14.0
45	1	28	71	155	5.5	6.8	2.0	5.7
46	2	23	74	185	4.0	7.3	2.0	4.9
47	2	23	72	178	12.3	11.6	3.3	13.1
48	0,1	24	72	162	3.3	8.6	2.8	6.0

DIVER PHYSICAL CHARACTERISTICS (cont.)

DVR NO.	PHASE@	AGE (YRS)	HT (IN)	WGT (LBS)	SKINFOLDS (mm) TRI	SS	SI	%FAT (NOTE 1)
49*	2	25	69	183	15.0	11.6	6.6	15.4
50*	0	24	70	196	9.0	8.5	2.8	9.7
51	3	34	72	208	16.6	18.3	10.6	21.8
52	0,1	36	72	189	11.3	10.6	3.8	15.8
53	0	22	69	166	5.0	10.8	3.0	8.8
54	3	25	69	158	5.6	11.6	3.3	9.8
55*	0	25	72	171	22.6	8.0	7.6	17.0
56*	2	29	71	170	6.5	8.5	2.0	7.7
57	0	26	73	204	15.0	16.0	7.5	17.1
58	0,1	29	68	170	11.1	10.8	14.3	16.4
59	3	27	71	192	18.8	18.0	13.1	20.2
60	3	21	72	167	6.1	8.0	3.5	8.1
61	1	23	73	210	8.5	10.1	6.0	11.9
62	1,2	29	75	192	8.8	11.0	3.0	11.0
63	3	34	78	252	14.1	16.0	11.0	20.8
64*	3	32	68	151	7.0	8.0	2.8	12.1
65*	3	37	79	216	8.8	9.8	4.6	14.8
66	2	29	66	177	12.3	12.0	3.0	13.1
67	3	24	70	169	10.8	9.1	2.8	11.0
68*	0,3	23	71	170	14.0	9.6	4.0	13.2
69*	0	23	71	184	7.0	11.0	5.3	11.3
70*	0,1,2,3	37	66	174	12.5	12.6	7.0	18.2
71*	0,3	27	70	183	4.8	10.8	3.1	8.7
72	3	23	69	174	4.6	10.1	4.0	8.7
73*	0,1	35	71	170	16.8	11.8	12.6	20.8
74	0	26	71	177	11.0	11.0	7.3	13.9
75	1	23	70	156	7.0	9.1	3.0	9.0
76	0	31	68	168	14.3	15.3	8.0	19.8
77	0	31	71	175	11.6	18.0	6.3	19.3
78*	3	38	68	197	11.6	17.3	11.1	20.5
79	3	32	73	201	13.8	21.3	9.1	21.5
80	1	31	72	186	17.3	17.0	6.6	20.7
81*	2	20	72	170	10.6	10.3	4.6	12.3
82*	1	35	69	173	9.6	20.0	9.6	20.3
83	3	21	68	175	10.0	8.1	4.1	10.7
84	3	34	68	171	11.3	16.0	9.0	19.4
85	1	23	70	180	5.0	8.6	3.6	7.8
86	3	22	72	162	3.0	6.5	2.3	3.6
87	0	26	68	166	5.3	8.3	2.6	7.1
88	0	33	69	175	8.6	15.6	6.3	17.6
89*	3	27	66	176	9.3	16.0	8.0	15.4
90	3	25	67	137	7.0	7.5	3.3	8.2
91*	3	32	63	183	5.0	15.1	7.0	16.4
92	1	20	71	174	10.3	12.0	4.6	12.9
93	2	22	74	178	6.0	7.0	2.0	6.2
94	1	21	65	155	8.6	11.0	4.8	11.8
95	1	43	73	205	16.0	15.3	9.0	23.5
96	1	37	72	160	4.0	9.3	3.0	11.2

DIVER PHYSICAL CHARACTERISTICS (cont.)

DVR NO.	PHASE @	AGE (YRS)	HT (IN)	WGT (LBS)	SKINFOLDS (mm) TRI	SS	SI	%FAT (NOTE 1)
97	3	27	67	168	13.1	11.3	7.0	14.7
98	0,1,3	32	70	191	8.3	13.0	7.0	16.8
99*	3	20	71	177	8.3	10.5	3.6	10.8
100	3	31	76	216	7.1	12.0	4.0	14.7
101	3	23	72	176	8.5	9.6	6.6	11.9
102*	1,2	24	68	150	4.0	7.6	1.6	4.8
103*	3	24	70	194	9.8	11.8	2.8	11.8
104*	2	24	70	160	9.5	8.1	4.0	10.4
105	2	29	71	179	7.3	7.0	2.0	7.2
106	1,2	39	73	202	6.5	15.5	5.0	16.4
107	1,3	27	71	192	7.8	16.0	11.0	15.9
108	0	24	72	187	11.6	8.0	4.3	11.6
109	0	34	71	198	20.8	22.8	10.6	23.7
110(F)*	0	30	62	126	12.6	11.0	10.8	25.8
111	1	24	67	145	4.1	10.3	1.5	6.9
112	1	26	70	157	6.8	10.0	3.0	9.4
113	2	36	69	185	13.3	10.3	6.6	17.5
114	3	26	68	208	8.6	11.5	10.5	14.4
115*	1,2	32	67	153	4.6	8.0	4.3	11.5
116	0	40	69	185	10.0	15.3	7.3	20.5
117*	0,1,2	32	71	207	17.5	28.0	12.3	24.4
118*	1,2,3	31	72	175	12.5	16.3	9.3	20.0
119	3	22	69	159	9.3	8.0	5.1	10.8
120	0	21	70	182	7.1	11.6	4.3	11.1
121*	0,1,2	22	71	172	4.6	9.5	3.5	8.1
122*	1	29	72	183	5.0	7.5	6.5	8.9
123	0,3	31	74	200	12.6	10.3	6.6	17.3
124	3	26	69	184	6.6	11.6	3.6	10.5
125	1	27	67	156	7.0	9.0	4.3	9.7
126	0,1,2	38	70	189	17.8	22.0	16.8	24.2

MEANS

		AGE	HT	WGT	%FAT
ALL SUBJS.	Mean	27.9	20.3	177	13.7
	s.d.	5.8	2.6	19.5	5.0
	N	126	126	126	126
SUBJS. WITH DCS*	Mean	28.1	20.2	179	14.5
	s.d.	5.5	3.0	20.5	4.8
	N	40	40	40	40
SUBJS. WITHOUT DCS	Mean	27.8	20.3	176	12.9
	s.d.	6.0	2.4	19.1	6.2
	N	86	86	86	86

@- Phase code 0=1A , 1=1B , 2=2 , 3=3
F-female
* Divers who suffered symptoms of decompression sickness

DIVER PHYSICAL CHARACTERISTICS (Cont.)

Note 1: Body fat percentage computed from triceps (TRI), subscapular (SS), and supra-iliac (SI) skinfolds according to the method of:

Durnin, J.V.G.A., and J. Womersley, Body Fat Assessed from Total Body Density and Its Estimation from Skinfold Thickness: Measurements on 481 Men and Women Aged from 16 to 72 Years. British Journal of Nutrition 32:77-97, 1974.

APPENDIX B

DECOMPRESSION SICKNESS DESCRIPTIONS

TABLE B-1

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE 1A

Table 4 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
a	24	8/24 VVAL22	150/60	(2) R. elbow pain and arm weakness, flexors and extensors.	5 min	Complete relief at 30 FSW on compression, Treatment Table 6.
	71			(1) Knee pain.	2 hrs	Pain initially abated. Recurred 3 hrs post dive in hot shower. Complete relief on arrival at 60 FSW. Treatment Table 5.
b	32	8/27 VVAL22	60/180	(1) L. knee pain, very mild. Fatigue.	7 hrs	Complete relief at 40 FSW on compression, Treatment Table 5.
c	69	9/4 VVAL22	150/60	(1) R. index finger, pain and stiffness.	20' stop	First noted 30 min before completing 20 FSW stop, increased in intensity 1 hr into 10 FSW stop. Complete relief on arrival at 60 FSW, Treatment Table 6.
	68			(2) R. lateral leg and thigh pain and paresthesias.	7 hrs	Did not report for treatment until 17 hrs post dive. Complete relief 30 min after arrival at 60 FSW, Treatment Table 6 with 1 extension at 60 FSW.
	55			(1) R. medial foot pain.	19 hrs	Pain severe enough to cause limping. Complete relief upon arrival at 60 FSW, Treatment Table 6.
d	71	9/6 Std.Air 60/200	60/180	(1) Bilat. hip pain, knee pain, mottling and itching of abdomen.	5 hrs	Complete relief after 4 min at 60 FSW, Treatment Table 5. Hip pain recurred next day. Complete relief after 6 min at 60 FSW Treatment Table 5.
	13			(1) R. shoulder pain. Fatigue.	4 1/2 hrs	Complete relief upon arrival at 60 FSW, Treatment Table 5.
	42			(1) R. shoulder pain. (1) L. knee pain.	60 FSW 4 hrs	Pulled shoulder on bottom. Mild pain on surfacing which increased over next 4 hrs at which time knee pain developed. Complete relief after 7 min at 60 FSW, Treatment Table 5.
e	110	9/7 VVAL25	60/180	(1) L. hip/groin pain(mild)	10' stop	L. hip pain did not change with surfacing. Complete relief upon arrival at 60 FSW, Treatment Table 5.
				(1) R. shoulder pain.	13 hrs	Shoulder ache developed 10 hrs post treatment which woke diver up but relieved by change in position. By 16 hrs post dive, developed R. arm paresthesias and swollen feeling of R. hand, with decreased manual dexterity. Compressed to 60 FSW with 50% relief of pain and 100% relief of paresthesia. Slight residual shoulder soreness after 1 extension of Treatment Table 6 at 60 FSW. Recurrence of shoulder pain at 52 FSW on decompression. Almost complete resolution on recompression to 60 FSW with mild residual soreness after 3 more O_2 periods. Shoulder pain increased with radiation to elbow with paresthesias on travel to 30 FSW. Substantial relief on compression to 60 FSW but mild residual soreness remained. Compressed to 100 FSW on 40% O_2/N_2 with complete relief. After 25 min decompressed to 60 FSW at 1 FSW/min. Given 2 O_2 periods at 60 FSW, decompressed on Treatment Table 6. Slight pain recurrence at 35 FSW which disappeared after 5 min on O_2. On surfacing only had signs of pulmonary O_2 toxicity. 3 days later developed R. shoulder pain and mild arm and hand paresthias. Diver was classical pianist and noted decreased R. hand dexterity on playing but was normal on physical examination. Also had leg pain. Given Treatment Table 5 with substantial improvement. Three days later (9/13) received another Treatment Table 5 because of decreased manual dexterity and R. shoulder and elbow pain. Over next 8 days given 5 additional treatments, some to 165 FSW. All treatments gave some relief and although symptoms returned between treatments, they did not return to pre-treatment intensity. Started on Motrin on 9/18. Last treatment on 9/21 followed by 1 month hiatus. At that time shoulder and elbow pain recurred after participation in softball and basketball games. Had three Treatment Table 6's over 4 days with no further improvement after 3rd treatment. At this time diagnosis of ulnar neuritis secondary to decompression sickness was made. Improved over next 3 months with manual dexterity returning to normal. Arm and elbow aching occurred with exposure to cold but symptoms barely noticeable. On 1/13/85 participated as subject in 5 day 60 FSW air saturation dive. Completely asymptomatic before and after this dive.

(CONTINUED)

TABLE B-1

(CONTINUED)

Table 4 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
e	50	9/7 VVAL25	60/180	(1) R. shoulder pain.	2 1/2 hrs	Complete relief after one O_2 period at 60 FSW, Treatment Table 6.
	55			(2) Extreme fatigue followed by nausea and bilat. lower extremity paresthesias.	3 hrs	Nausea gone after 5 min at 60 FSW. Complete relief after 2nd O_2 period. Treatment Table 6 with 1 extension at 60 FSW.
	70			(1) R. shoulder pain.	3 hrs	Complete relief upon arrival at 60 FSW, Treatment Table 5.
f	71	9/10 Std.Air 120/70	120/60	(1) L. shoulder pain (mild)	10' Stop	First noted at depth. Increased over 40 min post-dive. Complete relief upon arrival at 60 FSW, Treatment Table 5.
g	73	9/17 VVAL26	150/40	(1) R. knee pain.	5 hrs	Reported for treatment 15 hrs post dive. Complete relief after 3rd O_2 period at 60 FSW, Treatment Table 6, with 1 extension at 60 FSW.
h	37	9/20 VVAL26	150/40	(1) Shoulder pain.	7 hrs	Complete relief on compression to 60 FSW. Treatment Table 5.

TABLE B-2

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE 1B

Table 4 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
i	121	10/9 VVAL28	190/40	(1) R. knee ache. R. shoulder pain.	3 hrs	Knee ache initially fleeting. Complete relief of knee pain on compression to 60 FSW. 50% relief shoulder symptoms after 3rd O_2 period. Treatment Table 6 with 2 extensions at 60 FSW.
	82			(1) Ankle pain.	4 hrs	Complete relief after 3 O_2 periods at 60 FSW. Treatment Table 6 with 1 extension at 60 FSW.
j	118	10/16 VVAL28	120/80	(1) R. knee pain.	7 hrs	Substantial relief upon arrival at 60 FSW. Complete relief by 2nd O_2 period. Treatment Table 6. Recurred at 45 FSW during ascent, recompressed to 60 FSW, complete relief by 2nd O_2 period. Treatment Table 6 with 1 extension at 30 FSW.
	40			(2) Post-dive fatigue, Memory lapses, L. knee pain. Decreased sensation to pinprick R. temple and R. trunk. Decreased grip strength. Decreased neuropsychological function on Trails A, Symbol Digit Modality Test (SDMT) and Wechsler memory test.	40 hrs	Knee pain gone upon arrival at 60 FSW. Complete relief all symptoms after 3rd O_2 period. All neuropsychological tests WNL at 60 FSW except for SDMT which improved but not WNL. Treatment Table 6 with 2 extensions at 60 FSW and 1 extension at 30 FSW.
				(2) Difficulty remembering and concentrating. Low score on Thurston Test of Mental Alertness (TTMA). Flat affect.	96 hrs	Given Treatment Table 6. TTMA and affect normal after treatment. 48 hrs after this treatment still complained of poor concentration. Subjective improvement after completion of another Treatment Table 6.
k	122	10/18 VVAL28	120/70	(1) L. knee pain. (2) Decreased sensation over R. knee.	10' Stop 2 Min	Pain first noted at depth but went away. Recurred 2 min post-dive. Pain 80% gone on arrival at 60 FSW. Complete relief at 30 FSW after 1 extension at 60 FSW. Treatment Table 6.
	102			(1) L. elbow pain.	16 hrs	Complete relief at 30 FSW during compression. Treatment Table 5.
l	26	10/23 VVAL28	120/60	(1) R. shoulder and arm pain.	2.5 hrs	Pain mild at first, increased in intensity over next several hours. Reported for treatment 5 hrs post-dive. Shoulder pain gone on arrival at 60 FSW. Arm pain gone after 3rd O_2 period. Treatment Table 6 with 1 extension at 60 FSW.

TABLE B-3

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE 2

Table 5 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
m	49	11/5 VVAL28	150/40	(1) R. shoulder pain and mild sensation of arm heaviness.	10' stop	Sensation began just before surfacing. Complete relief upon arrival at 60 FSW, Treatment Table [illegible].
n	17	11/6 VVAL29	150/60 0.7ATA PO_2	(1) L. knee pain.	3 hrs	Complete relief upon arrival at 60 FSW, Treatment Table 5. 18 hrs after completing treatment had sudden onset L. shoulder pain. Compressed to 60 FSW with no change after 20 min. Because of pulmonary O_2 toxicity brought to surface at 2[illegible] FSW min. 3 days later, during a 150/40 0.7 ATA PO_2 dive, pain completely disappeared at 150 FSW and never returned.
	117			(1) L. elbow pain.	2.5 hrs	Complete relief after 10 min at 60 FSW, Treatment Table 5.
o	115	11/12 VVAL29	150/40 0.7ATA PO_2	(1) R. knee and elbow pain.	18 hrs	Elbow pain began 20 min after knee pain. Complete relief on arrival at 60 FSW, Treatment Table 5.
	2			(1) L. hand pain, 1st and 2nd metacarpal.	14 hrs	Complete relief after 10 min at 60 FSW, Treatment Table 5.
p	49	11/14	100/60, (90) 100/50 [#35]	(1) Bilat. elbow pain.	10' stop 2nd dive	Symptoms began 2 hrs before surfacing, very mild initially. Elbow pain gone at 50 FSW on compression, shoulder pain gone after 6 min at 60 FSW, Treatment Table 6.
	5			(1) R. knee pain.	Surface Interval	Noted onset putting on wetsuit for second dive. Pain gone as soon as water entered. Pain recurred a few min after surfacing from second dive. Complete relief at 36 FSW on compression, Treatment Table 5.
	104			(2) L. shoulder pain. L. arm paresthesia.	7 hrs 7.5 hrs	Reported for treatment 8.5 hrs post dive. Complete relief upon arrival at 60 FSW on compression. On arrival at 30 FSW on Treatment Table 6 had paresthesia over L. hip and rash over both hips. Recompressed to 60 FSW with 70% relief. Had 4 more O_2 periods at 60 FSW with very mild hip ache remaining. Complete relief after 2nd O_2 period at 30 FSW. Completed Treatment Table 6.
q	81	11/15 VVAL50	150/40, (90) 150/30 [#36]	(1) L. shoulder pain.	5 min	Complete relief upon arrival at 60 FSW, Treatment Table 5.
	115			(1) L. knee and elbow pain, very mild.	21 hrs	Complete relief after 8 min at 60 FSW, Treatment Table 5.
r	14	11/16 VVAL52	100/60, (90) 100/40 [#34]	(1) R. knee pain.	70' 1st dive	First noted on ascent from first dive. Increased slightly at 20 FSW, plateaued at 10 FSW. Increased over first 20 min after surfacing. Complete relief at 20 FSW on compression. Treatment Table 5.
s	5	11/26 VVAL52	100/ND, (60) 100/ND [#36]	(1) L. hip and shoulder, R. elbow pain.	40 min after 1st dive	Complete relief at 50 FSW on compression. Treatment Table 5.
	49			(1) L. shoulder and tricep.	3.5 hrs	On compression, 75% relief. Complete relief after 3rd O_2 period. Treatment Table 6.

#Profile number. See Table 2.

(CONTINUED)

TABLE B-3

(CONTINUED)

Table 5 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
t	56	11/28 VVAL54	100/ND, (60) 100/ND [#30]	(1) L. shoulder ache.	5 min 1st dive	Pain mild at first, increased in intensity over next 40 min. Complete relief after 10 min at 60 FSW. Treatment Table 5.
	27			(1) L. thumb pain, MCP joint.	5 min 1st dive	Resolved after 5 min, then recurred 20 min later and increased in intensity. Complete relief 10 min at 60 FSW. Treatment Table 5
	81			(1) L. elbow pain.	40 min 1st dive	Pain initially present immediately after 1st dive but resolved in a few min. Recurred and persisted 40 min later. Complete relief on arrival at 60 FSW, Treatment Table 5.
u	104	11/29 VVAL54	80/120	(1) L. shoulder pain.	14 hrs	Reported for treatment 16 hrs post dive. Complete relief at 14 FSW on compression, Treatment Table 5. Shoulder pain recurred next day (12/1), along with paresthesias and pain in R. hip. Complete relief of pain upon arrival at 60 FSW. Treatment Table 6 extended 2 O_2 periods at 60 FSW. Paresthesias 95% relief upon leaving 60 FSW. Paresthesias increased after first air break at 30 FSW. Recompressed to 60 FSW with almost complete relief after 1st O_2 period. Completed another Treatment Table 6 with complete relief upon surfacing.

#Profile number. See Table 2.

TABLE B-4

DECOMPRESSION SICKNESS DESCRIPTIONS

PHASE 3

Table 6 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
v	99	12/10 VVAL56	80/ND, (180) 80/ND [#29]	(1) R. shoulder pain.	10 min	Complete relief upon arrival at 60 FSW. Treatment Table 5.
	118 (T)			(1) R. knee and hip pain. Skin mottling.	5 min	Knee pain decreased by 20 min post dive, hip pain stayed same. Was tender during dive, 7 FSW shallower than divers. Breathed air. Complete relief after 3 min at 60 FSW. Treatment Table 5.
w	7	12/11 VVAL56	80/ND, (95) 80/ND [#28]	(1) R. elbow and shoulder pain.	13 min	Complete relief at 26 FSW during compression. Treatment Table 5.
x	91	12/11 VVAL58	100/ND, (60) 100/ND, (60) 100/ND [#31]	(1) R. shoulder pain.	1 min	Pain very slight post-dive. Increased in intensity overnight. Complete relief at 14 FSW during compression. Initially given Treatment Table 5. Pain recurred at 6 FSW, recompressed to 30 FSW with 95% relief. Recompressed further to 60 FSW without change. Started Treatment Table 6. No symptoms on surfacing.
	89			(1) L. shoulder ache.	4 hrs	Pain initially disappeared 1.5 hrs after onset. Recurred 6 hrs later. Complete relief at 14 FSW on recompression. Started on Treatment Table 5. Pain recurred at 6 FSW. Complete relief after 9 min at 60 FSW. Complete Treatment Table 6.
	122 (T)			(2) Light headedness. R. sided weakness.	5 min	Complete resolution after 20 min at 60 FSW. Was tender on dive 7 FSW shallower than other divers, breathed air throughout. Treatment Table 6 with 1 extension at 60 FSW.
y	78	12/13 VVAL58	80/ND, (95) 80/ND [#28]	(1) L. shoulder pain and skin rash.	90 min	Complete relief on arrival at 60 FSW, Treatment Table 5.
z	64	12/14 VVAL58	Multi-Level [#38]	(1) R. wrist pain.	4 hrs	50% relief on arrival at 60 FSW. 90% relief after 3rd O_2 period. Treatment Table 6. Mild recurrence at 30 FSW. Recompressed to 46 FSW with complete relief. Decompression on Treatment Table 6.
aa	33	12/17 VVAL58	Multi-Level [#37]	(1) R. shoulder, eblow, knee and ankle pain.	14 hrs	Symptoms mild at first upon awakening. Increased over next 6 hrs. Reported for treatment 22 hrs post-dive. Complete relief after 1 O_2 period at 60 FSW. Recurred at 44 FSW. Recompressed to 60 FSW with complete relief after 4 min. Restarted Treatment Table 6.

(CONTINUED)

(T) Tender
\# Profile number. See Table 2.

TABLE B-4

(CONTINUED)

Table 6 Key	Diver No.	Date '84 Mod	Profile FSW/Min	DCS Type and Location	Onset Time Post Dive	Comments
aa	65	12/17 VVAL58	Multi-Level [#37]	(2) L. knee pain with mild paresthesia just above L. knee.	72 hrs	Developed thigh pain during commercial airplane flight. Reported for treatment 18 hrs later. Complete relief during compression to 60 FSW. Treatment Table 6. At 30 FSW area hyperesthesia over knee occurred and resolved spontaneously. Extended one O_2 period at 30 FSW.
bb	103	12/18 VVAL58	Multi-Level [#38]	(1) R. wrist pain. (1) R. shoulder pain.	2 hrs 2.5 hrs	Wrist pain upon arrival at 60 FSW. Shoulder pain gone after 2nd O_2 period. Treatment Ta le 6. Shoulder pain recurred at 30 FSW. Compressed to 60 FSW. Only slight relief at 60 FSW. Treatment Table 6, all symptoms gone by end of treatment.

#Profile number. See Table 2.

APPENDIX C

INDIVIDUAL DIVING INTENSITY

TABLE C-1

PHASE 1A INDIVIDUAL DIVING INTENSITY

Body of Table Show Profile No. (Table 1; Appendix E)

Diver	August 1984						September 1984							Diver
No.	23	24	27	28	30	31	4	6	7	10	13	17	20	No.
8	8			5		8			8@	7	11	15	2	8
13			8					5*		7	14	15	2	13
16	8									7	14	2	2	16
18										7				18
21				5		8	16	5	8	7	11	15	2	21
22		16	8		3				8	11	14	2	15	22
23		16		5							14	15		23
24		16*						5		11	14	2		24
25	8			5		8	16		8	7	11	15	2	25
28			5										15	28
29	8					8	16		5	7	11	15		29
31						8	16				14			31
32			5*		3			5			11	15		32
37		16	8		3			5		11	14	2	15*	37
38	8			5			16		8	7	11		2	38
40			8		8									40
41	8			5		8	16		8	7	11	15	2	41
42	8		5					5*		7	14	15	2	42
48	8		5		8		16		5	7	14	15	2	48
50	8		5		8		16		5*	7	14	15	2	50
52	8		5			8				11	14	15	2	52
53	8			5		8	16		8	7	11	15	2	53
55			5		8		16*		5*					55
57				5			16			7				57
58					8								15	58
68			5		8		16*			7	14	15	2	68
69	8		5		8		16*		5	7	14	15	2	69
70	8					8	16		5*	7	14	15	2	70
71		16*	8		3			5*		11*	14	2	15	71
73	8											15*		73
74		16	8		3			5		11	14	2	15	74
76	8									11				76
77		16									11			77
87	8		5		8		16		5	7	14	15	2	87
88		16	8		3		16		5	7		15		88
98							16		5					98
108		16	8		3			5		11	14	2	15	108
109					8				8				2	109
110							16		5*					110
116	8			5									2	116
117	8									11	14			117
120		16	8		3			5		11	14	2	15	120
121	8			5		8	16		8	7	11	15	2	121
123			8									2	2	123
126	8				3		16		8				15	126

@ Did Not Complete Dive
* Decompression Sickness

TABLE C-2

PHASE 1B INDIVIDUAL DIVING INTENSITY

Body of Table Shows Profile No. (Table 1, Appendix E)

Diver No.	October 1984													Diver No.
	3	4	5	9	12	15	16	18	19	22	23	25	26	
4		9		17	18		13		1		11		4	4
6		9		17	18@		13		1	20		21		6
8	15			17	10	18		12						8
9									1					9
13			9		10							21		13
21	15		9	17	10	1		12		20		21		21
22								12						22
25	15		9	17	10	1		12		20			4@	25
26	15@			19	10	18		4			11*		4	26
31					18					20		21		31
32	15			17	18	1		12						32
33	15			19	10	18		4			11			33
34				17	18									34
37		9		17			13		1	20		21		37
40							13*							40
42		9								20		21		42
43						1		4						43
45		9		17	18		13		1		11		4@	45
48	15			17	10	1		12			11		4	48
52	15			17	10				1	20				52
58	15				10	18		4		20		21		58
61	15			19	10	18		4			11		4	61
62	15			19	10	18		4		20		21		62
70	15		9	17	10		13			20		21		70
73			9							20		21		73
75	15			19	10	18		4						75
80						18		4						80
82				19*										82
85		9		17	18		13		1		11		4	85
92		9		17	18				1	20		21		92
94	15@		9	17@	10@	1		12			11		4	94
95										20				95
96	15			19	10	18		4			11			96
98						1								98
102	15		9	17	10	1		12*		20@		21		102
106	15									20		21		106
107	15		9	17	10	1		12		20		21		107
111		9		17	10		13		1	20		21		111
112	15			19	10	18		4		20			4	112
115	15				18				1			21		115
117		9								20		21		117
118		9		17	18		13*				11		4	118
121				19*										121
122	15		9	17	10	1		12*		20		21		122
125												21		125
126				19			13							126

@ Did Not Complete Dive
* Decompression Sickness

TABLE C-3

PHASE 2 INDIVIDUAL DIVING INTENSITY

Body of Table Shows Profile No. (Tables 1 & 2, Appendix E)

Diver No.	Nov. 5	6	8	9	12	13	14	15	16	19	20	26	27	28	29	30	Diver No.
2	20		11		22*			36		25		26		30		30	2
5	15		11		22		35*			25		30*@			6		5
10	20		11		22			36		25		26		30		30	10
11	15		11		22		35			25		30			6		11
12	15		11		22		35			25		30			6		12
14		23		22		36			34@*		26		6		6		14
17		23*		22					34@		26		6				17
27	20		11		22			36		25		26		30*@		30	27
31												26				30	31
32														30		30	32
37	15		11				35			25		30			6		37
39		23		22		36			34		26		6		6		39
44	20		11		22			36		25		26		30		30	44
46	15		11		22		35			25		30					46
47		23		22		36			34		26		6			30	47
49	15*		11		22		35*			25		30*					49
56	20		11		22			36		25		26		30*@		30	56
62	15		11		22		35			25		30			6		62
66	15		11		22		35			25		30			6		66
70	20		11		22			36		25		26		30		30	70
81	20@		11		22			36*		25		26		30*@			81
93	20		11		22			36		25		26		30		30	93
102		23		22@		36			34		26		6			30	102
104	15		11		22		35*			25		30			6*		104
105	15		11		22		35			25		30					105
106														30		30	106
113		23		22		36			34		26		6			30	113
115	20		11		22*			36*		25		26					115
117		23*		22		36			34		26		6@			30	117
118		23		22		36			34		26		6		6		118
121		23		22		36@			34		26		6			30	121
126																30	126

@ Did Not Complete Dive
* Decompression Sickness

TABLE C-4

PHASE 3 INDIVIDUAL DIVING INTENSITY

Body of Table Shows Profile No. (Tables 1 & 2, Appendix E)

Diver No.	December 1984									Diver No.
	10	11	12	13	14	17	18	19	20	
1		28		29		32		37		1
3	29		31		27	37		32		3
7		28*		29		32		37		7
15	29		27		38		33		24	15
19		31		28		32			24	19
20	29		31		27	37		32		20
29		28		29		32		37		29
30		28		29		32		37		30
31							33		24	31
33		28		29		37*			24	33
35		31		28				32		35
36		28		29		32		37		36
38	29		31		27	37		32		38
51		28		29		32		37		51
54	29		27		38		33		24	54
59	29		31		27	37		32		59
60	29		31		27	37		32		60
63		31		28			38		24	63
64	29		27		38*		33		24	64
65	29		31		27	37*				65
67	29		31		27	37		32		67
68	29		27		38		33		24	68
70	29		27		38		33		24	70
71		31		28			38		24	71
72		31		28			38			72
78				28*@			38		24	78
79	29		27		38		33		24	79
83	29		31		27	37		32		83
84	29		27		38				24	84
88		31		28			38		24	88
89		31*			27			37		89
90	29		27		38		33		24	90
91		31*					38		24	91
97		28		29		32		37		97
98										98
99	29*		31@	28		37		32		99
100										100
101	29		27		38		33		24	101
103		31		28			38*			103
107		31		28			38		24	107
114	29		27		38		33		24	114
118 T	29*									118T
119		28		21@		32		37		119
122 T		31*								122T
123	29		31		27			32		123
124		28		29		32		37		124

@ Did Not Complete Dive
* Decompression Sickness
T Tender

APPENDIX D

Maximum Permissible Tissue Tension

(MPTT)

Tables

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL18- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	120.000	98.000	78.000	56.000	48.500	45.500	44.500	44.000	43.500
20 FSW	130.000	108.000	88.000	66.000	58.500	55.500	54.500	54.000	53.500
30 FSW	140.000	118.000	98.000	76.000	68.500	65.500	64.500	64.000	63.500
40 FSW	150.000	128.000	108.000	86.000	78.500	75.500	74.500	74.000	73.500
50 FSW	160.000	138.000	118.000	96.000	88.500	85.500	84.500	84.000	83.500
60 FSW	170.000	148.000	128.000	106.000	98.500	95.500	94.500	94.000	93.500
70 FSW	180.000	158.000	138.000	116.000	108.500	105.500	104.500	104.000	103.500
80 FSW	190.000	168.000	148.000	126.000	118.500	115.500	114.500	114.000	113.500
90 FSW	200.000	178.000	158.000	136.000	128.500	125.500	124.500	124.000	123.500
100 FSW	210.000	188.000	168.000	146.000	138.500	135.500	124.500	134.000	133.500
110 FSW	220.000	198.000	178.000	156.000	148.500	145.500	144.500	144.000	143.500
120 FSW	230.000	208.000	188.000	166.000	158.500	155.500	154.500	154.000	153.500
130 FSW	240.000	218.000	198.000	176.000	168.500	165.500	164.500	164.000	163.500
140 FSW	250.000	228.000	208.000	186.000	178.500	175.500	174.500	174.000	173.500
150 FSW	260.000	238.000	218.000	196.000	188.500	185.500	184.500	184.000	183.500
160 FSW	270.000	248.000	228.000	206.000	198.500	195.500	194.500	194.000	193.500
170 FSW	280.000	258.000	238.000	216.000	208.500	205.500	204.500	204.000	203.500
180 FSW	290.000	268.000	248.000	226.000	218.500	215.500	214.500	214.000	213.500
190 FSW	300.000	278.000	258.000	236.000	228.500	225.500	224.500	224.000	223.500
200 FSW	310.000	288.000	268.000	246.000	238.500	235.500	234.500	234.000	233.500
210 FSW	320.000	298.000	278.000	256.000	248.500	245.500	244.500	244.000	243.500
220 FSW	330.000	308.000	288.000	266.000	258.500	255.500	254.500	254.000	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	265.500	264.500	264.000	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	275.500	274.500	274.000	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	285.500	284.500	284.000	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	295.500	294.500	294.000	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	305.500	304.500	304.000	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	315.500	314.500	314.000	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	325.500	324.500	324.000	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	335.500	334.500	334.000	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

FAC 2	PH2O	PVCO2	PVO2	AMBAO2	PEQVP
1.50	0.00	2.30	2.00	0.00	0.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL22- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .72 SDR	10 MIN .72 SDR	20 MIN .72 SDR	40 MIN .72 SDR	80 MIN .72 SDR	120 MIN .72 SDR	160 MIN .72 SDR	200 MIN .72 SDR	240 MIN .72 SDR
10 FSW	120.760	98.760	78.760	56.760	49.260	46.260	45.260	44.760	44.260
20 FSW	130.590	108.590	88.590	66.590	59.090	56.090	55.090	54.590	54.090
30 FSW	140.500	118.500	98.500	76.500	69.000	66.000	65.000	64.500	64.000
40 FSW	150.410	128.410	108.410	86.410	78.910	75.910	74.910	74.410	73.910
50 FSW	160.360	138.360	118.360	96.360	88.860	85.860	84.860	84.360	83.860
60 FSW	170.280	148.280	128.280	106.280	98.760	95.780	94.780	94.280	93.780
70 FSW	180.190	158.190	138.190	116.190	108.690	105.690	104.690	104.190	103.690
80 FSW	190.060	168.060	148.060	126.060	118.560	115.560	114.560	114.060	113.560
90 FSW	199.960	177.960	157.960	135.960	128.460	125.460	124.460	123.960	123.460
100 FSW	209.820	187.820	167.820	145.820	138.320	135.320	134.320	133.820	133.320
110 FSW	219.690	197.690	177.690	155.690	148.190	145.190	144.190	143.690	143.190
120 FSW	229.490	207.490	187.490	165.490	157.990	154.990	153.990	153.490	152.990
130 FSW	239.150	217.150	197.150	175.150	167.650	164.650	163.650	163.150	162.650
140 FSW	248.840	226.840	206.840	184.840	177.340	174.340	173.340	172.840	172.340
150 FSW	258.490	236.490	216.490	194.490	186.990	183.990	182.990	182.490	181.990
160 FSW	268.020	246.020	226.020	204.020	196.520	193.520	192.520	192.020	191.520
170 FSW	277.240	255.240	235.240	213.240	205.740	202.740	201.740	201.240	200.740
180 FSW	286.240	264.240	244.240	222.240	214.740	211.740	210.740	210.240	209.740
190 FSW	294.760	272.760	252.760	230.760	223.260	220.260	219.260	218.760	218.260
200 FSW	303.030	281.030	261.030	239.030	231.530	228.530	227.530	227.030	226.530
210 FSW	320.000	298.000	278.000	256.000	248.500	245.500	244.500	244.000	243.500
220 FSW	330.000	308.000	288.000	266.000	258.500	255.500	254.500	254.000	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	265.500	264.500	264.000	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	275.500	274.500	274.000	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	285.500	284.500	284.000	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	295.500	294.500	294.000	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	305.500	304.500	304.000	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	315.500	314.500	314.000	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	325.500	324.500	324.000	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	335.500	334.500	334.000	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	PBOVP
1.70	2.00	1.87	2.80	2.46	10.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL25: NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.00 SDR	10 MIN 1.00 SDR	20 MIN 1.00 SDR	40 MIN 1.00 SDR	80 MIN 1.00 SDR	120 MIN 1.00 SDR	160 MIN 1.00 SDR	200 MIN 1.00 SDR	240 MIN 1.00 SDR
10 FSW	120.760	98.760	78.760	56.760	49.260	46.260	45.260	44.760	44.260
20 FSW	130.590	108.590	88.590	66.590	59.090	56.090	55.090	54.590	54.090
30 FSW	140.500	118.500	98.500	76.500	69.000	66.000	65.000	64.500	64.000
40 FSW	150.410	128.410	108.410	86.410	78.910	75.910	74.910	74.410	73.910
50 FSW	160.360	138.360	118.360	96.360	88.860	85.860	84.860	84.360	83.860
60 FSW	170.280	148.280	128.280	106.280	98.780	95.780	94.780	94.280	93.780
70 FSW	180.190	158.190	138.190	116.190	108.690	105.690	104.690	104.190	103.690
80 FSW	190.060	168.060	148.060	126.060	118.560	115.560	114.560	114.060	113.560
90 FSW	199.960	177.960	157.960	135.960	128.460	125.460	124.460	123.960	123.460
100 FSW	209.820	187.820	167.820	145.820	138.320	135.320	134.320	133.820	133.320
110 FSW	219.690	197.690	177.690	155.690	148.190	145.190	144.190	143.690	143.190
120 FSW	229.490	207.490	187.490	165.490	157.990	154.990	153.990	153.490	152.990
130 FSW	239.150	217.150	197.150	175.150	167.650	164.650	163.650	163.150	162.650
140 FSW	248.840	226.840	206.840	184.840	177.340	174.340	173.340	172.840	172.340
150 FSW	258.490	236.490	216.490	194.490	186.990	183.990	182.990	182.490	181.990
160 FSW	268.020	246.020	226.020	204.020	196.520	193.520	192.520	192.020	191.520
170 FSW	277.240	255.240	235.240	213.240	205.740	202.740	201.740	201.240	200.740
180 FSW	286.240	264.240	244.240	222.240	214.740	211.740	210.740	210.240	209.740
190 FSW	294.760	272.760	252.760	230.760	223.260	220.260	219.260	218.760	218.260
200 FSW	303.030	281.030	261.030	239.030	231.530	228.530	227.530	227.030	226.530
210 FSW	320.000	298.000	278.000	256.000	248.500	245.500	244.500	244.000	243.500
220 FSW	330.000	308.000	288.000	266.000	258.500	255.500	254.500	254.000	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	265.500	264.500	264.000	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	275.500	274.500	274.000	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	285.500	284.500	284.000	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	295.500	294.500	294.000	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	305.500	304.500	304.000	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	315.500	314.500	314.000	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	325.500	324.500	324.000	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	335.500	334.500	334.000	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	PBOVP
1.70	2.00	1.87	2.60	2.46	10.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL26- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.90 SDR	10 MIN 1.70 SDR	20 MIN 1.55 SDR	40 MIN 1.35 SDR	80 MIN 1.00 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .33 SDR
10 FSW	120.760	98.760	78.760	56.760	49.260	46.260	45.260	44.760	44.260
20 FSW	130.590	108.590	88.590	66.590	59.090	56.090	55.090	54.590	54.090
30 FSW	140.560	118.500	98.500	76.500	69.000	66.000	65.000	64.500	64.000
40 FSW	150.410	128.410	108.410	86.410	78.910	75.910	74.910	74.410	73.910
50 FSW	160.360	138.360	118.360	96.360	88.860	85.860	84.860	84.360	83.860
60 FSW	170.280	148.280	128.280	106.280	98.780	95.780	94.780	94 280	93 780
70 FSW	180.190	158.190	138.190	116.190	108.690	105.690	104.690	104.190	103.690
80 FSW	190.060	168.060	148.060	126.060	118.560	115.560	114.560	114.060	113.560
90 FSW	199.960	177.960	157.960	135.960	128.460	125.460	124.460	123.960	123.460
100 FSW	209.820	187.820	167.820	145.820	138.320	135.320	134.320	133.820	133.320
110 FSW	219.690	197.690	177.690	155.690	148.190	145.190	144.190	143.690	143.190
120 FSW	229.490	207.490	187.490	165.490	157.990	154.990	153.990	153.490	152.990
130 FSW	239.150	217.150	197.150	175.150	167.650	164.650	163.650	163.150	162.650
140 FSW	248.840	226.840	206.840	184.840	177.340	174.340	173.340	172.840	172 340
150 FSW	258.490	236.490	216.490	194.490	186.990	183.990	182.990	182.490	181.990
160 FSW	268.020	246.020	226.020	204.020	196.520	193.520	192.520	192.020	191.520
170 FSW	277.240	255.240	235.240	213.240	205.740	202.740	201.740	201.240	200.740
180 FSW	286.240	264.240	244.240	222.240	214.740	211.740	210.740	210.240	209.740
190 FSW	294.760	272.760	252.760	230.760	223.260	220.260	219.260	218.760	218.260
200 FSW	303.030	281.030	261.030	239.030	231.530	228.530	227.530	227.030	226 530
210 FSW	320.000	298.000	278.000	256.000	248.500	245.500	244.500	244.000	243.500
220 FSW	330.000	308.000	288.000	266.000	258.500	255.500	254.500	254.000	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	265.500	264.500	264.000	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	275.500	274.500	274.000	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	285.500	284.500	284.000	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	295.500	294.500	294.000	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	305.500	304.500	304.000	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	315.500	314.500	314.000	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	325.500	324.500	324.000	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	330.500	334.500	334.000	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	PBOVP
1.76	2.00	1.87	2.80	2.46	10.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL28- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.30 SDR	10 MIN 1.70 SDR	20 MIN 1.55 SDR	40 MIN 1.75 SDR	80 MIN 1.00 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .33 SDR
10 FSW	120.760	98.760	78.760	56.760	49.260	45.010	44.760	44.510	44.260
20 FSW	130.590	108.590	88.590	66.590	59.090	54.840	54.590	54.340	54.090
30 FSW	140.500	118.500	98.500	76.500	69.000	64.750	64.500	64.250	64.000
40 FSW	150.410	128.410	108.410	86.410	78.910	74.660	74.410	74.160	73.910
50 FSW	160.360	138.360	118.360	96.360	88.860	84.610	84.360	84.110	83.860
60 FSW	170.280	148.280	128.280	106.280	98.780	94.530	94.280	94.030	93.760
70 FSW	180.190	158.190	138.190	116.190	108.690	104.440	104.190	103.940	103.690
80 FSW	190.060	168.060	148.060	126.060	118.560	114.310	114.060	113.810	113.560
90 FSW	199.960	177.960	157.960	135.960	128.460	124.210	123.960	123.710	123.460
100 FSW	209.820	187.820	167.820	145.820	138.320	134.070	133.820	133.570	133.320
110 FSW	219.690	197.690	177.690	155.690	148.190	143.940	143.690	143.440	143.190
120 FSW	229.490	207.490	187.490	165.490	157.990	153.740	153.490	153.240	152.990
130 FSW	239.150	217.150	197.150	175.150	167.650	163.400	163.150	162.900	162.650
140 FSW	248.840	226.840	206.840	184.840	177.340	173.090	172.840	172.590	172.340
150 FSW	258.490	236.490	216.490	194.490	186.990	182.740	182.490	182.240	181.990
160 FSW	268.020	246.020	226.020	204.020	196.520	192.270	192.020	191.770	191.520
170 FSW	277.240	255.240	235.240	213.240	205.740	201.490	201.240	200.990	200.740
180 FSW	286.240	264.240	244.240	222.240	214.740	210.490	210.240	209.990	209.740
190 FSW	294.760	272.760	252.760	230.760	223.260	219.010	218.760	218.510	218.260
200 FSW	303.030	281.030	261.030	239.030	231.530	227.280	227.030	226.780	226.530
210 FSW	320.000	298.000	278.000	256.000	248.500	244.250	244.000	243.750	243.500
220 FSW	330.000	308.000	289.000	266.000	258.500	254.250	254.000	253.750	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	264.250	264.000	263.750	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	274.250	274.000	273.750	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	284.250	284.000	283.750	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	294.250	294.000	293.750	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	304.250	304.000	303.750	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	314.250	314.000	313.750	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	324.250	324.000	323.750	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	334.250	334.000	333.750	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

FACO2	FH2O	PVCO2	FVO2	AMBAO2	PEOVF
1.30	2.00	1.87	2.80	2.46	10.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL29- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.80 SDR	10 MIN 1.70 SDR	20 MIN 1.55 SDR	40 MIN 1.35 SDR	80 MIN 1.00 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .33 SDR
10 FSW	120.000	98.000	78.000	56.000	48.500	44.250	44.000	43.750	43.500
20 FSW	130.000	108.000	88.000	66.000	58.500	54.250	54.000	53.750	53.500
30 FSW	140.000	118.000	98.000	76.000	68.500	64.250	64.000	63.750	63.500
40 FSW	150.000	128.000	108.000	86.000	78.500	74.250	74.000	73.750	73.500
50 FSW	160.000	138.000	118.000	96.000	88.500	84.250	84.000	83.750	83.500
60 FSW	170.000	148.000	128.000	106.000	98.500	94.250	94.000	93.750	93.500
70 FSW	180.000	158.000	138.000	116.000	108.500	104.250	104.000	103.750	103.500
80 FSW	190.000	168.000	148.000	126.000	118.500	114.250	114.000	113.750	113.500
90 FSW	200.000	178.000	158.000	136.000	128.500	124.250	124.000	123.750	123.500
100 FSW	210.000	188.000	168.000	146.000	138.500	134.250	134.000	133.750	133.500
110 FSW	220.000	198.000	178.000	156.000	148.500	144.250	144.000	143.750	143.500
120 FSW	230.000	208.000	188.000	166.000	158.500	154.250	154.000	153.750	153.500
130 FSW	240.000	218.000	198.000	176.000	168.500	164.250	164.000	163.750	163.500
140 FSW	250.000	228.000	208.000	186.000	178.500	174.250	174.000	173.750	173.500
150 FSW	260.000	238.000	218.000	196.000	188.500	184.250	184.000	183.750	183.500
160 FSW	270.000	248.000	228.000	206.000	198.500	194.250	194.000	193.750	193.500
170 FSW	280.000	258.000	238.000	216.000	208.500	204.250	204.000	203.750	203.500
180 FSW	290.000	268.000	248.000	226.000	218.500	214.250	214.000	213.750	213.500
190 FSW	300.000	278.000	258.000	236.000	228.500	224.250	224.000	223.750	223.500
200 FSW	310.000	288.000	268.000	246.000	238.500	234.250	234.000	233.750	233.500
210 FSW	320.000	298.000	278.000	256.000	248.500	244.250	244.000	243.750	243.500
220 FSW	330.000	308.000	288.000	266.000	258.500	254.250	254.000	253.750	253.500
230 FSW	340.000	318.000	298.000	276.000	268.500	264.250	264.000	263.750	263.500
240 FSW	350.000	328.000	308.000	286.000	278.500	274.250	274.000	273.750	273.500
250 FSW	360.000	338.000	318.000	296.000	288.500	284.250	284.000	283.750	283.500
260 FSW	370.000	348.000	328.000	306.000	298.500	294.250	294.000	293.750	293.500
270 FSW	380.000	358.000	338.000	316.000	308.500	304.250	304.000	303.750	303.500
280 FSW	390.000	368.000	348.000	326.000	318.500	314.250	314.000	313.750	313.500
290 FSW	400.000	378.000	358.000	336.000	328.500	324.250	324.000	323.750	323.500
300 FSW	410.000	388.000	368.000	346.000	338.500	334.250	334.000	333.750	333.500

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW=1 ATA)

PACO2	PH2O	PVCO2	PVO2	AMBAO2	PBOVP
1.70	2.00	1.87	2.80	2.46	10.000

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL50- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN 1.80 SDR	10 MIN 1.70 SDR	20 MIN 1.55 SDR	40 MIN 1.35 SDR	80 MIN 1.00 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .33 SDR
10 FSW	126.670	114.670	84.670	62.670	55.170	50.920	50.670	50.420	50.170
20 FSW	136.670	124.670	94.670	72.670	65.170	60.920	60.670	60.420	60.170
30 FSW	146.670	134.670	104.670	82.670	75.170	70.920	70.670	70.420	70.170
40 FSW	156.670	144.670	114.670	92.670	85.170	80.920	80.670	80.420	80.170
50 FSW	166.670	154.670	124.670	102.670	95.170	90.920	90.670	90.420	90.170
60 FSW	176.670	164.670	134.670	112.670	105.170	100.920	100.670	100.420	100.170
70 FSW	186.670	174.670	144.670	122.670	115.170	110.920	110.670	110.420	110.170
80 FSW	196.670	184.670	154.670	132.670	125.170	120.920	120.670	120.420	120.170
90 FSW	206.670	194.670	164.670	142.670	135.170	130.920	130.670	130.420	130.170
100 FSW	216.670	204.670	174.670	152.670	145.170	140.920	140.670	140.420	140.170
110 FSW	226.670	214.670	184.670	162.670	155.170	150.920	150.670	150.420	150.170
120 FSW	236.670	224.670	194.670	172.670	165.170	160.920	160.670	160.420	160.170
130 FSW	246.670	234.670	204.670	182.670	175.170	170.920	170.670	170.420	170.170
140 FSW	256.670	244.670	214.670	192.670	185.170	180.920	180.670	180.420	180.170
150 FSW	266.670	254.670	224.670	202.670	195.170	190.920	190.670	190.420	190.170
160 FSW	276.670	264.670	234.670	212.670	205.170	200.920	200.670	200.420	200.170
170 FSW	286.670	274.670	244.670	222.670	215.170	210.920	210.670	210.420	210.170
180 FSW	296.670	284.670	254.670	232.670	225.170	220.920	220.670	220.420	220.170
190 FSW	306.670	294.670	264.670	242.670	235.170	230.920	230.670	230.420	230.170
200 FSW	316.670	304.670	274.670	252.670	245.170	240.920	240.670	240.420	240.170
210 FSW	326.670	314.670	284.670	262.670	255.170	250.920	250.670	250.420	250.170
220 FSW	336.670	324.670	294.670	272.670	265.170	260.920	260.670	260.420	260.170
230 FSW	346.670	334.670	304.670	282.670	275.170	270.920	270.670	270.420	270.170
240 FSW	356.670	344.670	314.670	292.670	285.170	280.920	280.670	280.420	280.170
250 FSW	366.670	354.670	324.670	302.670	295.170	290.920	290.670	290.420	290.170
260 FSW	376.670	364.670	334.670	312.670	305.170	300.920	300.670	300.420	300.170
270 FSW	386.670	374.670	344.670	322.670	315.170	310.920	310.670	310.420	310.170
280 FSW	396.670	384.670	354.670	332.670	325.170	320.920	320.670	320.420	320.170
290 FSW	406.670	394.670	364.670	342.670	335.170	330.920	330.670	330.420	330.170
300 FSW	416.670	404.670	374.670	352.670	345.170	340.920	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DPAO2 (VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PEUVP	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	(FSW)

TARLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL52- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .96 SDR	10 MIN .96 SDR	20 MIN .96 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	84.670	62.670	55.170	50.920	50.670	50.420	50.170
20 FSW	136.670	124.670	94.670	72.670	65.170	60.920	60.670	60.420	60.170
30 FSW	146.670	134.670	104.670	82.670	75.170	70.920	70.670	70.420	70.170
40 FSW	156.670	144.670	114.670	92.670	85.170	80.920	80.670	80.420	80.170
50 FSW	166.670	154.670	124.670	102.670	95.170	90.920	90.670	90.420	90.170
60 FSW	176.670	164.670	134.670	112.670	105.170	100.920	100.670	100.420	100.170
70 FSW	186.670	174.670	144.670	122.670	115.170	110.920	110.670	110.420	110.170
80 FSW	196.670	184.670	154.670	132.670	125.170	120.920	120.670	120.420	120.170
90 FSW	206.670	194.670	164.670	142.670	135.170	130.920	130.670	130.420	130.170
100 FSW	216.670	204.670	174.670	152.670	145.170	140.920	140.670	140.420	140.170
110 FSW	226.670	214.670	184.670	162.670	155.170	150.920	150.670	150.420	150.170
120 FSW	236.670	224.670	194.670	172.670	165.170	160.920	160.670	160.420	160.170
130 FSW	246.670	234.670	204.670	182.670	175.170	170.920	170.670	170.420	170.170
140 FSW	256.670	244.670	214.670	192.670	185.170	180.920	180.670	180.420	180.170
150 FSW	266.670	254.670	224.670	202.670	195.170	190.920	190.670	190.420	190.170
160 FSW	276.670	264.670	234.670	212.670	205.170	200.920	200.670	200.420	200.170
170 FSW	286.670	274.670	244.670	222.670	215.170	210.920	210.670	210.420	210.170
180 FSW	296.670	284.670	254.670	232.670	225.170	220.920	220.670	220.420	220.170
190 FSW	306.670	294.670	264.670	242.670	235.170	230.920	230.670	230.420	230.170
200 FSW	316.670	304.670	274.670	252.670	245.170	240.920	240.670	240.420	240.170
210 FSW	326.670	314.670	284.670	262.670	255.170	250.920	250.670	250.420	250.170
220 FSW	336.670	324.670	294.670	272.670	265.170	260.920	260.670	260.420	260.170
230 FSW	346.670	334.670	304.670	282.670	275.170	270.920	270.670	270.420	270.170
240 FSW	356.670	344.670	314.670	292.670	285.170	280.920	280.670	280.420	280.170
250 FSW	366.670	354.670	324.670	302.670	295.170	290.920	290.670	290.420	290.170
260 FSW	376.670	364.670	334.670	312.670	305.170	300.920	300.670	300.420	300.170
270 FSW	386.670	374.670	344.670	322.670	315.170	310.920	310.670	310.420	310.170
280 FSW	396.670	384.670	354.670	332.670	325.170	320.920	320.670	320.420	320.170
290 FSW	406.670	394.670	364.670	342.670	335.170	330.920	330.670	330.420	330.170
300 FSW	416.670	404.670	374.670	352.670	345.170	340.920	340.670	340.420	340.170

BLOOD PAFAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DHAO2 (VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PEOVP	22.00	20.00	18.00	15.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL53- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .96 SDR	10 MIN .96 SDR	20 MIN .96 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	84.670	61.670	55.170	51.920	50.670	50.420	50.170
20 FSW	136.670	124.670	94.670	71.670	65.170	61.920	60.670	60.420	60.170
30 FSW	146.670	134.670	104.670	81.670	75.170	71.920	70.670	70.420	70.170
40 FSW	156.670	144.670	114.670	91.670	85.170	81.920	80.670	80.420	80.170
50 FSW	166.670	154.670	124.670	101.670	95.170	91.920	90.670	90.420	90.170
60 FSW	176.670	164.670	134.670	111.670	105.170	101.920	100.670	100.420	100.170
70 FSW	186.670	174.670	144.670	121.670	115.170	111.920	110.670	110.420	110.170
80 FSW	196.670	184.670	154.670	131.670	125.170	121.920	120.670	120.420	120.170
90 FSW	206.670	194.670	164.670	141.670	135.170	131.920	130.670	130.420	130.170
100 FSW	216.670	204.670	174.670	151.670	145.170	141.920	140.670	140.420	140.170
110 FSW	226.670	214.670	184.670	161.670	155.170	151.920	150.670	150.420	150.170
120 FSW	236.670	224.670	194.670	171.670	165.170	161.920	160.670	160.420	160.170
130 FSW	246.670	234.670	204.670	181.670	175.170	171.920	170.670	170.420	170.170
140 FSW	256.670	244.670	214.670	191.670	185.170	181.920	180.670	180.420	180.170
150 FSW	266.670	254.670	224.670	201.670	195.170	191.920	190.670	190.420	190.170
160 FSW	276.670	264.670	234.670	211.670	205.170	201.920	200.670	200.420	200.170
170 FSW	286.670	274.670	244.670	221.670	215.170	211.920	210.670	210.420	210.170
180 FSW	296.670	284.670	254.670	231.670	225.170	221.920	220.670	220.420	220.170
190 FSW	306.670	294.670	264.670	241.670	235.170	231.920	230.670	230.420	230.170
200 FSW	316.670	304.670	274.670	251.670	245.170	241.920	240.670	240.420	240.170
210 FSW	326.670	314.670	284.670	261.670	255.170	251.920	250.670	250.420	250.170
220 FSW	336.670	324.670	294.670	271.670	265.170	261.920	260.670	260.420	260.170
230 FSW	346.670	334.670	304.670	281.670	275.170	271.920	270.670	270.420	270.170
240 FSW	356.670	344.670	314.670	291.670	285.170	281.920	280.670	280.420	280.170
250 FSW	366.670	354.670	324.670	301.670	295.170	291.920	290.670	290.420	290.170
260 FSW	376.670	364.670	334.670	311.670	305.170	301.920	300.670	300.420	300.170
270 FSW	386.670	374.670	344.670	321.670	315.170	311.920	310.670	310.420	310.170
280 FSW	396.670	384.670	354.670	331.670	325.170	321.920	320.670	320.420	320.170
290 FSW	406.670	394.670	364.670	341.670	335.170	331.920	330.670	330.420	330.170
300 FSW	416.670	404.670	374.670	351.670	345.170	341.920	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	22.00	20.00	18.00	11.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL54- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDP	10 MIN .50 SDP	20 MIN .55 SDP	40 MIN .60 SDP	80 MIN .96 SDP	120 MIN .72 SDP	160 MIN .60 SDP	200 MIN .45 SDP	240 MIN .40 SDP
10 FSW	126.670	114.670	84.670	61.670	55.170	51.920	50.670	50.420	50.170
20 FSW	136.670	124.670	94.670	71.670	65.170	61.920	60.670	60.420	60.170
30 FSW	146.670	134.670	104.670	81.670	75.170	71.920	70.670	70.420	70.170
40 FSW	156.670	144.670	114.670	91.670	85.170	81.920	80.670	80.420	80.170
50 FSW	166.670	154.670	124.670	101.670	95.170	91.920	90.670	90.420	90.170
60 FSW	176.670	164.670	134.670	111.670	105.170	101.920	100.670	100.420	100.170
70 FSW	186.670	174.670	144.670	121.670	115.170	111.920	110.670	110.420	110.170
80 FSW	196.670	184.670	154.670	131.670	125.170	121.920	120.670	120.420	120.170
90 FSW	206.670	194.670	164.670	141.670	135.170	131.920	130.670	130.420	130.170
100 FSW	216.670	204.670	174.670	151.670	145.170	141.920	140.670	140.420	140.170
110 FSW	226.670	214.670	184.670	161.670	155.170	151.920	150.670	150.420	150.170
120 FSW	236.670	224.670	194.670	171.670	165.170	161.920	160.670	160.420	160.170
130 FSW	246.670	234.670	204.670	181.670	175.170	171.920	170.670	170.420	170.170
140 FSW	256.670	244.670	214.670	191.670	185.170	181.920	180.670	180.420	180.170
150 FSW	266.670	254.670	224.670	201.670	195.170	191.920	190.670	190.420	190.170
160 FSW	276.670	264.670	234.670	211.670	205.170	201.920	200.670	200.420	200.170
170 FSW	286.670	274.670	244.670	221.670	215.170	211.920	210.670	210.420	210.170
180 FSW	296.670	284.670	254.670	231.670	225.170	221.920	220.670	220.420	220.170
190 FSW	306.670	294.670	264.670	241.670	235.170	231.920	230.670	230.420	230.170
200 FSW	316.670	304.670	274.670	251.670	245.170	241.920	240.670	240.420	240.170
210 FSW	326.670	314.670	284.670	261.670	255.170	251.920	250.670	250.420	250.170
220 FSW	336.670	324.670	294.670	271.670	265.170	261.920	260.670	260.420	260.170
230 FSW	346.670	334.670	304.670	281.670	275.170	271.920	270.670	270.420	270.170
240 FSW	356.670	344.670	314.670	291.670	285.170	281.920	280.670	280.420	280.170
250 FSW	366.670	354.670	324.670	301.670	295.170	291.920	290.670	290.420	290.170
260 FSW	376.670	364.670	334.670	311.670	305.170	301.920	300.670	300.420	300.170
270 FSW	386.670	374.670	344.670	321.670	315.170	311.920	310.670	310.420	310.170
280 FSW	396.670	384.670	354.670	331.670	325.170	321.920	320.670	320.420	320.170
290 FSW	406.670	394.670	364.670	341.670	335.170	331.920	330.670	330.420	330.170
300 FSW	416.670	404.670	374.670	351.670	345.170	341.920	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	36.00	36.00	36.00	29.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL55- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	77.000	61.170	54.800	51.920	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	71.170	64.800	61.920	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	81.170	74.800	71.920	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	91.170	84.800	81.920	80.670	80.420	80.170
50 FSW	166.670	154.670	117.000	101.170	94.800	91.920	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	111.170	104.800	101.920	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	121.170	114.800	111.920	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	131.170	124.800	121.920	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	141.170	134.800	131.920	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	151.170	144.800	141.920	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	161.170	154.800	151.920	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	171.170	164.800	161.920	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	181.170	174.800	171.920	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	191.170	184.800	181.920	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	201.170	194.800	191.920	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	211.170	204.800	201.920	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	221.170	214.800	211.920	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	231.170	224.800	221.920	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	241.170	234.800	231.920	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	251.170	244.800	241.920	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	261.170	254.800	251.920	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	271.170	264.800	261.920	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	281.170	274.800	271.920	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	291.170	264.800	281.920	280.670	260.420	280.170
250 FSW	366.670	354.670	317.000	301.170	294.800	291.920	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	311.170	304.800	301.920	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	321.170	314.800	311.920	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	331.170	324.800	321.920	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	341.170	334.800	331.920	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	351.170	344.800	341.920	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAPO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.67	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	36.00	36.00	29.00	19.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL56- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	77.000	62.500	54.800	51.700	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	72.500	64.800	61.700	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	82.500	74.800	71.700	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	92.500	84.800	81.700	80.670	80.420	80.170
50 FSW	166.670	154.670	117.000	102.500	94.800	91.700	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	112.500	104.800	101.700	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	122.500	114.800	111.700	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	132.500	124.800	121.700	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	142.500	134.800	131.700	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	152.500	144.800	141.700	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	162.500	154.800	151.700	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	172.500	164.800	161.700	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	182.500	174.800	171.700	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	192.500	184.800	181.700	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	202.500	194.800	191.700	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	212.500	204.800	201.700	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	222.500	214.800	211.700	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	232.500	224.800	221.700	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	242.500	234.800	231.700	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	252.500	244.800	241.700	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	262.500	254.800	251.700	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	272.500	264.800	261.700	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	282.500	274.800	271.700	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	292.500	284.800	281.700	280.670	280.420	280.170
250 FSW	366.670	354.670	317.000	302.500	294.800	291.700	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	312.500	304.800	301.700	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	322.500	314.800	311.700	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	332.500	324.800	321.700	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	342.500	334.800	331.700	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	352.500	344.800	341.700	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAPO2(VOL %)
1.70	2.00	.170

CH/O2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PROVP	36.00	36.00	29.00	19.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL5S- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .90 SDR	80 MIN .96 SDR	120 MIN .72 SDF	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDF
10 FSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	71.510	64.800	61.700	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	81.510	74.800	71.700	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	91.510	84.800	81.700	80.670	80.420	80.170
50 FSW	166.670	154.670	117.000	101.510	94.800	91.700	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	111.510	104.800	101.700	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	121.510	114.800	111.700	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	131.510	124.800	121.700	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	141.510	134.800	131.700	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	151.510	144.800	141.700	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	161.510	154.800	151.700	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	171.510	164.800	161.700	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	181.510	174.800	171.700	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	191.510	184.800	181.700	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	201.510	194.800	191.700	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	211.510	204.800	201.700	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	221.510	214.800	211.700	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	231.510	224.800	221.700	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	241.510	234.800	231.700	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	251.510	244.800	241.700	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	261.510	254.800	251.700	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	271.510	264.800	261.700	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	281.510	274.800	271.700	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	291.510	284.800	281.700	280.670	280.420	280.170
250 FSW	366.670	354.670	317.000	301.510	294.800	291.700	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	311.510	304.800	301.700	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	321.510	314.800	311.700	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	331.510	324.800	321.700	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	341.510	334.800	331.700	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	351.510	344.800	341.700	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL79- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .85 SDR	80 MIN .9[illegible] SDR	120 MIN .66 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	71.510	64.800	61.700	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	81.510	74.800	71.700	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	91.510	84.800	81.700	80.670	80.420	90.170
50 FSW	166.670	154.670	117.000	101.510	94.800	91.700	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	111.510	104.800	101.700	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	121.510	114.800	111.700	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	131.510	124.800	121.700	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	141.510	134.800	131.700	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	151.510	144.800	141.700	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	161.510	154.800	151.700	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	171.510	164.800	161.700	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	181.510	174.800	171.700	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	191.510	184.800	181.700	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	201.510	194.800	191.700	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	211.510	204.800	201.700	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	221.510	214.800	211.700	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	231.510	224.800	221.700	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	241.510	234.800	231.700	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	251.510	244.800	241.700	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	261.510	254.800	251.700	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	271.510	264.800	261.700	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	281.510	274.800	271.700	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	291.510	284.800	281.700	280.670	280.420	280.170
250 FSW	366.670	354.670	317.000	301.510	294.800	291.700	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	311.510	304.800	301.700	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	321.510	314.800	311.700	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	331.510	324.800	321.700	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	341.510	334.800	331.700	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	351.510	344.800	341.700	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW: 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PFOVR	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

APPENDIX E

DIVE PROFILE COMPARISONS

TABLE E-1

Dive Profile Comparison: Air Decompression Bounce

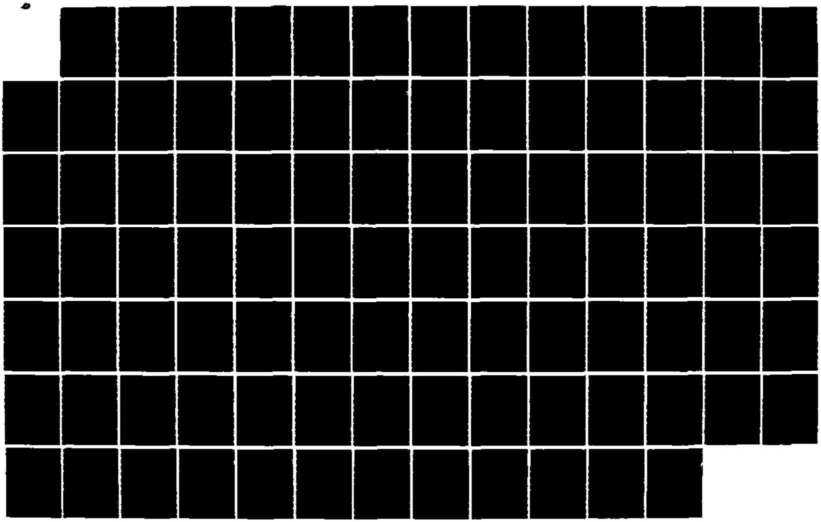
Profiles FSW/Min	VVAL	STOPS (FSW) 20	10	Total Decomp. Time (min:sec)
Profile #1	Std Air	9	47	47:50
	18		229	238:50
	22		135	135:50
50/240	25		97	97:50
	26		135	135:50
	28*		158	158:50
	50	1	157	158:50
	52	1	194	195:50
	53	1	183	184:50
	54	1	183	184:50
	55	3	181	184:50
	56	3	181	184:50
	58	3	181	184:50
	59	3	186	189:50
Profile #3	Std Air*		14	15:00
	18		69	70:00
	22		38	39:00
60/100	25		28	29:00
	26		22	23:00
	28*		22	23:00
	50		23	24:00
	52		24	25:00
	53		31	32:00
	54		28	29:00
	55		27	28:00
	56		27	28:00
	58		30	31:00
	59		31	32:00
Profile #4	Std Air		26	27:00
	18		123	124:00
	22		67	68:00
60/120	25		48	49:00
	26		48	49:00
	28*		56	57:00
	50		59	60:00
	52		71	72:00
	53	2	49	52:00
	54	2	49	52:00
	55	2	51	54:00
	56		54	55:00
	58	2	57	56:00
	59	2	56	59:00

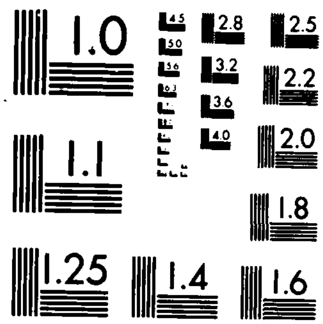
(Continued)

* Profiles Actually Tested.

AD-A173 999 AIR-N2O2 DECOMPRESSION COMPUTER ALGORITHM DEVELOPMENT 2/2
(U) NAVY EXPERIMENTAL DIVING UNIT PANAMA CITY FL
E D THALMANN AUG 86 NEDU-8-85

UNCLASSIFIED F/G 6/19 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TABLE E-1 (Continued)

Dive Profile Comparison: Air Decompression Bounce

Profiles FSW/Min	VVAL	STOPS (FSW) 30	20	10	Total Decomp. Time (min:sec)
	Std Air			56	57:00
Profile #5	(60/200)*		1	69	71:00
	18		48	205	254:00
	22*		28	124	153:00
60/180	25*		20	90	111:00
	26		20	132	153:00
	28		20	155	176:00
	50		21	154	176:00
	52		21	191	213:00
	53		21	170	192:00
	54		21	170	192:00
	55		24	168	193:00
	56		24	172	197:00
	58		24	172	197:00
	59		24	183	208:00
Profile #6	Std Air		17	56	74:20
	18	21	69	184	275:20
	22	14	49	112	176:20
80/120	25	10	36	80	127:20
	26	7	37	127	172:20
	28	7	37	149	194:20
	50	3	36	150	195:20
	52	8	38	186	233:20
	53*	13	34	166	214:20
	54*	14	32	168	215:20
	55	11	38	163	213:20
	56	8	41	166	216:20
	58	13	36	168	218:20
	59	14	35	182	232:20
Profile #8	Std Air*		9	28	38:40
	(100/70)*		17	39	57:40
	18		64	93	158:40
	22*		43	56	100:40
100/60	25*		31	40	72:40
	26		23	35	59:40
	28		23	35	59:40
	50		23	38	62:40
	52		25	43	69:40
	53		34	38	73:40
	54		32	34	67:40
	55	4	20	42	67:40
	56	4	17	45	67:40
	58	4	28	36	69:40
	59	4	30	39	74:40

(Continued)

*Profiles Actually Tested.

TABLE E-1 (Continued)

Dive Profile Comparison: Air Decompression Bounce

Profiles FSW/Min	VVAL	STOPS (FSW) 40	30	20	10	Total Decomp. Time (min:sec)
	Std Air		3	23	57	84:40
Profile #9	18	3	55	70	155	284:40
	22	1	44	49	105	200:40
100/90	25	1	31	35	76	144:40
	26	1	23	33	128	186:40
	28*	1	23	33	151	209:40
	50	1	22	34	150	208:40
	52	1	25	33	188	248:40
	53	4	30	34	163	232:40
	54	4	30	32	165	232:40
	55	4	21	38	164	228:40
	56	1	22	39	167	230:40
	58	4	30	32	170	237:40
	59	4	32	34	179	250:40
	Std Air		2	22	45	71:00
Profile #11	(120/70)*		9	23	55	89:00
	18		52	69	92	215:00
	22		39	49	63	153:00
120/60	25		28	35	46	111:00
	26		21	26	76	125:00
	28*		21	26	98	147:00
	50		20	26	100	148:00
	52		23	27	121	173:00
	53		31	33	93	159:00
	54		30	32	94	158:00
	55	8	15	23	109	157:00
	56	8	14	21	116	161:00
	58	8	21	33	103	167:00
	59	8	23	34	110	177:00
	Std Air		9	23	55	89:00
Profile #12	18	22	55	69	141	289:00
	22	17	44	49	99	211:00
120/70	25	12	32	35	71	152:00
	26	9	23	30	124	188:00
	28*	9	23	30	147	211:00
	50	9	23	30	147	211:00
	52	10	26	29	183	250:00
	53	15	30	34	154	235:00
	54	16	30	32	156	236:00
	55	13	21	35	158	229:00
	56	13	18	37	162	232:00
	58	15	29	33	160	239:00
	59	16	31	34	170	253:00

(Continued)

*Profiles Actually Tested.

TABLE E-1 (Continued)

Dive Profile Comparison: Air Decompression Bounce

Profiles FSW/Min	VVAL	STOPS (FSW) 60	50	40	30	20	10	Total Decomp. Time (min:sec)
	Std Air				15	27	63	107:00
Profile #13	18			42	56	69	196	365:00
	22			35	43	50	135	265:00
120/80	25			25	31	36	97	191:00
	26			18	24	47	155	246:00
	28*			18	24	51	170	265:00
	50			18	23	53	169	265:00
	52			21	25	60	208	316:00
	53			27	31	37	223	320:00
	54			28	30	37	223	320:00
	55		3	18	22	54	210	309:00
	56		3	15	22	56	106	304:00
	58		3	24	29	44	219	321:00
	59		3	26	31	46	220	328:00
	Std Air				5	19	33	59:30
Profile #15	18			9	28	69	93	201:30
	22			7	22	48	56	135:30
150/40	25			5	15	36	40	98:30
	26*			3	12	26	42	85:30
	28*			3	12	26	53	96:30
	50			3	12	26	57	100:30
	52			4	13	27	68	114:30
	53			4	19	34	42	101:30
	54			4	21	32	43	102:30
	55		2	13	14	15	65	111:30
	56		2	13	14	14	70	115:30
	58		2	13	14	25	62	118:30
	59		2	13	14	29	64	124:30
	Std Air			3	19	26	62	112:30
Profile #16	18		18	45	55	70	196	383:30
	22*		16	38	43	50	134	283:30
150/60	25		11	28	31	35	97	204:30
	26		8	20	24	46	152	252:30
	28		8	20	24	48	171	273:30
	50		8	20	23	50	168	271:30
	52		9	23	26	57	207	324:30
	53		13	28	30	37	224	334:30
	54		15	28	30	37	226	338:30
	55	8	13	13	20	59	217	332:30
	56	8	13	13	17	62	215	330:30
	58	8	13	18	30	50	224	345:30
	59	8	13	21	31	53	222	350:30

(Continued)

TABLE E-1 (Continued)

Dive Profile Comparison: Air Decompression Bounce

Profiles FSW/Min	VVAL	STOPS (FSW) 70	60	50	40	30	20	10	Total Decomp. Time (min:sec)
	Std Air				1	8	19	32	63:10
Profile #18	18		3	10	11	26	56	92	201:10
	22		3	9	9	20	41	57	142:10
190/30	25		2	6	7	14	30	41	103:10
	26		1	3	5	10	25	43	90:10
	28*		1	3	5	10	25	52	99:10
	50			1	8	10	24	54	100:10
	52			1	10	11	25	65	115:10
	53			1	10	15	34	39	102:10
	54			3	9	19	32	41	107:10
	55			11	13	14	14	69	124:10
	56			11	13	14	14	73	128:10
	58			11	13	14	21	68	130:10
	59			11	13	14	25	70	136:10
	Std Air				8	14	23	55	103:10
Profile #19	18	3	8	20	23	50	69	170	346:10
	22	3	8	17	20	40	49	113	253:10
190/40	25	2	5	13	14	29	36	77	179:10
	26*	1	3	9	11	23	32	125	207:10
	28*	1	3	9	11	23	32	147	229:10
	50		5	8	10	23	32	147	228:10
	52		6	10	12	25	32	186	274:10
	53		6	10	19	30	34	160	262:10
	54		7	11	23	30	32	164	270:10
	55	6	11	13	13	13	48	178	285:10
	56	6	11	13	13	13	48	183	290:10
	58	6	11	13	13	23	38	187	294:10
	59	6	11	13	13	27	35	202	310:10

*Profiles Actually Tested.

TABLE E-2

Dive Profile Comparison: 0.7 ATA O_2-N_2 Bounce

Constant 0.7 ATA O_2 in N_2

Profiles FSW/Min	VVAL	STOPS (FSW) 70	60	50	40	30	20	10	Total Decomp. Time (min:sec)
Profile #20	18					7	28	28	64:40
	29*					3	15	27	46:40
	52					4	18	27	50:40
100/60	58					7	20	20	48:40
	59					7	21	22	51:40
Profile #21	18			1	7	8	17	29	64:30
	29*				3	4	10	15	34:30
	52				1	8	12	18	41:30
150/30	58				9	11	11	16	49:30
	59				9	11	11	19	52:30
Profile #22	18			7	15	19	28	28	99:30
	29*			3	6	12	15	45	84:30
	52			4	8	14	18	48	94:30
150/40	58		3	11	11	11	17	46	101:30
	59		3	11	11	11	20	48	106:30
Profile #23	18	4	14	22	28	29	30	75	204:30
	29*	1	7	13	15	14	57	100	209:30
	52	2	8	15	18	18	58	111	232:30
150/60	58	11	11	11	19	20	55	132	261:30
	59	11	11	11	22	21	58	128	264:30

Air → Constant 0.7 ATA PO_2 in N_2

Profile #24	18							38	39:00
	29							34	35:00
	52							37	38:00
60/120	58						2	28	31:00
	59*						2	30	33:00
Profile #25	18				2	28	29	47	107:40
	29				1	15	20	75	112:40
	52*				1	18	19	83	122:40
100/90	58				4	20	20	73	118:40
	59				4	22	21	77	125:40
Profile #26	18				6	15	28	28	79:30
	29				3	8	15	26	54:30
	52*				3	10	18	25	58:30
150/40	58			2	11	11	14	21	61:30
	59			2	11	11	16	22	64:30

*Profiles Actually Tested.

TABLE E-3

Dive Profile Comparison: Air No-Decompression Repets

Body of table shows No-Decompression Time in minutes which includes descent time at 60 FSW/min.

Profiles FSW/Min	VVAL	1st Excursion	TDT#	2nd Excursion	TDT#
Profile #27	Std Air	40		8	
		{40}@	0	{22} + [32]@	19
	18	40.18		8.21	
	22	41.72		15.39	
80 ND	25	41.78		20.22	
	26	41.85		25.72	
60 Min S.I.	28	41.85		25.72	
	50	41.42		26.63	
80/ND	52	41.35		26.18	
	53	39.49		20.97	
	54	39.49		22.11	
	55	38.59		26.55	
	56	39.19		28.78	
	58*	39.19		22.13	
	59	39.19		21.17	
Profile #28	Std Air	40		12	
		{40}@	0	{39} + [28]@	25
	18	40.18		12.04	
	22	41.72		22.35	
80/ND	25	41.78		28.95	
	26	41.85		34.98	
95 Min S.I.	28	41.85		34.98	
	50	41.42		35.28	
80/ND	52	41.35		33.37	
	53	39.49		29.48	
	54	39.41		27.99	
	55	38.59		32.17	
	56	39.19		34.51	
	58*	39.19		29.93	
	59	39.19		30.06	
Profile #29	Std Air	40		22	
		{40}@	0	{39} + [18]@	19
	18	40.18		20.39	
	22	41.72		34.00	
80/ND	25	41.78		39.07	
	26	41.85		40.95	
180 Min S.I.	28	41.85		40.95	
	50	41.42		40.62	
80/ND	52	41.35		39.51	
	53	39.49		37.21	
	54	39.49		35.01	
	55	38.59		37.09	
	56*	39.19		38.45	
	58*	39.19		36.88	
	59	39.19		36.48	

TABLE E-3 (Continued)

Dive Profile Comparison: Air No-Decompression Repets

Body of table shows No-Decompression Time in minutes which includes descent time at 60 FSW/min.

Profiles FSW/Min	VVAL	1st Excursion TDT#	2nd Excursion TDT#	3rd Excursion TDT#
Profile #30	Std Air	25	-1	---------
		{30}@ 5	{20} + [26]@ 28	---------
	18	29.73	5.81	---------
	22	30.78	10.84	---------
100/ND	25	30.78	14.28	---------
	26	30.78	18.30	---------
60 Min S.I.	28	30.78	18.30	---------
	50	30.49	19.02	---------
100/ND	52*	30.49	18.23	---------
	53	29.25	14.99	---------
	54*	29.25	15.84	---------
	55*	26.50	20.06	---------
	56	26.50	20.15	---------
	58	26.50	17.74	---------
	59	26.50	18.06	---------
Profile #31	Std Air	25	-1	
		{30}@ 5	{20} + [26]@ 28	{19}+ [38]@ 39
	18	29.73	5.81	5.81
	22	30.78	10.84	10.84
100/ND	25	30.78	14.28	14.28
	26	30.78	18.30	18.30
60 Min S.I.	28	30.78	18.30	18.30
	50	30.49	19.02	18.42
100/ND	52	30.49	18.73	15.67
	53	29.25	14.99	14.99
60 Min S.I.	54	29.25	15.84	15.84
	55	26.50	20.06	18.94
100/ND	56	26.50	20.15	18.86
	58*	26.50	17.74	15.89
	59	26.50	18.06	15.15

(Continued)

TABLE E-3 (Continued)

Dive Profile Comparison: Air No-Decompression Repets

Body of table shows No-Decompression Time in minutes which includes descent time at 60 FSW/min.

Profiles FSW/Min	VVAL	1st Excursion	TDT#	2nd Excursion	TDT#
Profile #32	Std Air	15		0	
		{20}@	4	{14} + [21]@	32
	18	23.34		4.85	
	22	23.92		8.86	
120/ND	25	24.36		11.18	
	26	24.45		14.29	
60 Min S.I.	28	24.45		14.29	
	50	24.24		14.87	
120/ND	52	24.24		14.65	
	53	23.31		11.72	
	54	23.31		12.39	
	55	20.21		15.04	
	56	20.21		15.04	
	58*	20.21		14.63	
	59	20.21		14.14	
Profile #33	Std Air	5		0	
		{15}@	6	{1} + [14]@	24
	18	14.58		6.79	
	22	14.79		7.31	
150/ND	25	15.58		11.04	
	26	16.45		12.66	
95 Min S.I.	28	16.45		12.66	
	50	18.09		11.67	
80/ND	52	16.16		12.58	
	53	16.16		10.34	
	54	14.42		10.96	
	55	14.42		11.23	
	56	14.42		11.23	
	58*	14.42		11.23	
	59	14.42		11.23	

* Profiles Actually Tested.
\# Total Decompression Time required by Standard Air Schedule.
@ Times in { } are bottom time, times in [ ] Residual Nitrogen time according to Standard Air Tables (see text).

S.I. Surface Interval
ND No Decompression

TABLE E-4

Dive Profile Comparison: Air Decompression Repets

Profiles FSW/Min	VVAL	1st DIVE STOPS (FSW) 50	40	30	20	10	1st DIVE Total Decomp. Time (min:sec)	2nd DIVE STOPS (FSW) 40	30	20	10	2nd DIVE Total Decomp. Time (min:sec)
	Std Air				9	28	38:40		3	23	57	84:40
Profile #34	18				17	39	57:40		1	69	137	208:40
	22				64	93	158:40			32	76	109:40
100/60	25				43	56	100:40			14	51	66:40
	26				31	40	72:40			2	120	123:40
90 Min S.I.	28				23	35	59:40			2	143	146:40
	50				23	35	59:40				140	141:40
100/40	52*				23	38	62:40			2	189	192:40
	53				25	43	69:40			13	155	169:40
	54				34	38	73:40			15	157	173:40
	55				32	34	67:40			6	167	174:40
	56			4	20	42	67:40			6	171	178:40
	58			4	28	36	69:40			11	166	178:40
	59			4	30	39	74:40			14	177	192:40
	Std Air				9	28	38:40		7	23	66	97:40
Profile #35	18				17	39	57:40		24	70	165	260:40
	22				64	93	158:40		6	49	102	158:40
100/60	25				43	56	100:40			33	65	99:40
	26				31	40	72:40			22	150	173:40
90 Min S.I.	28*				23	35	59:40			22	170	193:40
	50				23	35	59:40			19	167	187:40
100/50	52				23	38	62:40			36	207	244:40
	53				25	43	69:40			31	207	239:40
	54				34	38	73:40			31	210	242:40
	55				32	34	67:40			23	216	240:40
	56			4	20	42	67:40			24	214	239:40
	58			4	28	36	69:40			29	213	243:40
	59			4	30	39	74:40			32	216	249:40
	Std Air			5	19	33	59:30	3	19	26	62	112:30
Profile #36	18		9	28	69	93	201:30	2	55	69	156	285:30
	22		7	22	48	56	135:30		28	49	106	185:30
150/40	25		5	15	36	40	98:30		11	35	66	114:30
	26		3	12	26	42	85:30		2	28	163	195:30
90 Min S.I.	28*		3	12	26	53	96:30		2	27	173	204:30
	50*		3	12	26	57	100:30		1	23	173	199:30
150/30	52		4	13	27	68	114:30			43	208	253:30
	53		4	19	34	42	101:30		8	35	229	274:30
	54		4	21	32	43	102:30		10	34	230	276:30
	55	2	13	14	15	65	111:30		15	30	238	285:30
	56	2	13	14	14	70	115:30		14	32	234	282:30
	58	2	13	14	25	62	118:30		14	32	238	286:30
	59	2	13	14	29	64	124:30		14	37	234	287:30

* Profiles Actually Tested.

TABLE E-5

Dive Profile Comparison: Multi-Level Air/Constant 0.7 ATA PO_2 in N_2

Profiles FSW/Min	VVAL	STOPS (FSW)	10	Total Decomp. Time (min:sec)
Profile #37	Std Air	80/360		280:20
	18		74	75:20
80/60 (Air)	28	Final Decompression from	60	61:20
20/180 (0.7 PO_2)	29	80 FSW	75	76:20
80/50 (Air)	52	after	76	77:20
	58	50 min	60	61:20
	59*		68	69:20
Profile #38	Std Air	100/360		416:40
	18		11	12:00
80/60 (Air)	28	Final Decompression from	33	34:00
100/120(0.7 PO_2)	29	60 FSW	48	49:00
100/20 (0.7 PO_2)	52	after	43	43:00
20/60 (0.7 PO_2)	58*	40 min	27	27:00
60/40 (Air)	59*		34	34:00

* Profiles Actually Tested.

Note: No decompression stops were required until arrival at 10 FSW during final ascent to the surface.

APPENDIX F

AIR DECOMPRESSION TABLES (VVAL59)

Tables in feet with 10 FSW Stop Depth Increment and in meters with 3 MSW Stop Depth Increments

MPTT Tables are included for reference in FSW and MSW.

TABLES IN FEET

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL59- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .85 SDR	80 MIN .96 SDR	120 MIN .68 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	71.510	64.800	61.700	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	81.510	74.800	71.700	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	91.510	84.800	81.700	80.670	80.420	80.170
50 FSW	166.670	154.670	117.000	101.510	94.800	91.700	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	111.510	104.800	101.700	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	121.510	114.800	111.700	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	131.510	124.800	121.700	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	141.510	134.800	131.700	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	151.510	144.800	141.700	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	161.510	154.800	151.700	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	171.510	164.800	161.700	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	181.510	174.800	171.700	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	191.510	184.800	181.700	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	201.510	194.800	191.700	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	211.510	204.800	201.700	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	221.510	214.800	211.700	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	231.510	224.800	221.700	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	241.510	234.800	231.700	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	251.510	244.800	241.700	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	261.510	254.800	251.700	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	271.510	264.800	261.700	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	281.510	274.800	271.700	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	291.510	284.800	281.700	280.670	280.420	280.170
250 FSW	366.670	354.670	317.000	301.510	294.800	291.700	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	311.510	304.800	301.700	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	321.510	314.800	311.700	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	331.510	324.800	321.700	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	341.510	334.800	331.700	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	351.510	344.800	341.700	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
P2OVP	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
40	167	0:40												0	0:40
40	200	0:30												15	15:40
40	210	0:30												25	25:40
40	230	0:30												48	48:40
40	250	0:30												68	68:40
40	270	0:30												86	86:40
40	300	0:30												110	110:40
limit line															
40	360	0:30												165	165:40
40	480	0:30												325	325:40
40	720	0:20											7	604	611:40
50	88	0:50												0	0:50
50	90	0:40												1	1:50
50	100	0:40												6	6:50
50	110	0:40												11	11:50
50	120	0:40												14	14:50
50	140	0:40												30	30:50
50	160	0:40												61	61:50
50	180	0:40												99	99:50
50	200	0:40												132	132:50
50	220	0:40												163	163:50
50	240	0:30											3	186	189:50
60	61	1:00												0	1:00
60	70	0:50												9	10:00
60	80	0:50												18	19:00

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
60	100	0:50												31	32:00
60	120	0:40											2	56	59:00
60	140	0:40											8	108	117:00
60	160	0:40											13	152	166:00
60	180	0:40											24	183	208:00
60	200	0:40											36	213	250:00
60	240	0:40											85	313	399:00
60	360	0:30										9	203	602	815:00
60	480	0:30										57	353	734	1145:00
60	720	0:30										158	588	749	1496:00
70	47	1:10												0	1:10
70	50	1:00												4	5:10
70	60	1:00												18	19:10
70	70	1:00												30	31:10
70	80	0:50											2	38	41:10
70	90	0:50											10	38	49:10
70	100	0:50											16	59	76:10
70	110	0:50											21	91	113:10
70	120	0:50											26	120	147:10
70	130	0:50											30	146	177:10
70	140	0:50											34	172	207:10
70	150	0:40										1	43	191	236:10
70	160	0:40										3	50	210	264:10
70	170	0:40										5	63	226	295:10

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
80	39	1:20												0	1:20
80	40	1:10												2	3:20
80	50	1:10												22	23:20
80	60	1:10												38	39:20
80	70	1:00											12	38	51:20
80	80	1:00											22	39	62:20
80	90	1:00											31	75	107:20
80	100	0:50										4	34	112	151:20
80	110	0:50										9	35	147	192:20
80	120	0:50										14	35	182	232:20
80	130	0:50										18	43	206	268:20
80	140	0:50										21	58	222	302:20
80	150	0:50										24	83	254	362:20
limit	line	----------													
80	160	0:50										38	141	368	548:20
80	240	0:40									8	97	200	616	922:20
80	360	0:40									64	178	491	749	1483:20
80	480	0:40									121	342	622	749	1835:20
80	720	0:30								19	287	541	637	748	2233:20
90	31	1:30												0	1:30
90	40	1:20												17	18:30
90	50	1:10											3	36	40:30
90	60	1:10											17	38	56:30
90	70	1:10											31	38	70:30
90	80	1:00										8	34	84	127:30

TBLF1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
90	90	1:00										[illegible]	35	128	190:30
90	100	1:00										24	34	169	227:30
90	110	1:00										30	37	205	273:30
90	120	0:50									4	31	58	222	316:30
90	130	0:50									5	41	69	263	[illegible]
100	26	1:40												0	1:40
100	30	1:30												6	7:40
100	40	1:20											4	28	33:40
100	50	1:20											16	39	56:40
100	60	1:10										4	30	39	74:40
100	70	1:10										14	35	81	131:40
100	80	1:10										26	34	132	193:40
100	90	1:00									4	32	34	179	250:40
100	100	1:00									12	31	42	220	306:40
100	110	1:00									15	32	78	247	373:40
100	120	1:00									24	31	113	304	473:40
limit line															
100	180	0:50								13	30	116	220	624	100[illegible]:40
100	240	0:50								23	91	167	428	747	1457:40
100	360	0:40							8	99	159	407	637	749	2060:40
100	480	0:40							39	142	332	578	636	749	2477:40
100	720	0:40							104	327	488	554	636	749	2859:40
110	22	1:50												0	1:50
110	25	1:40												5	6:50
110	30	1:40												15	16:50

* TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
110	40	1:30											12	34	47:50
110	50	1:20										7	24	39	71:50
110	60	1:20										16	34	67	118:50
110	70	1:10									4	27	34	127	193:50
110	80	1:10									12	31	35	181	260:50
110	90	1:10									22	31	48	220	322:50
110	100	1:00								2	28	31	91	269	422:50
120	20	2:00												0	2:00
120	25	1:50												12	14:00
120	30	1:40											6	21	29:00
120	40	1:30										6	15	36	61:00
120	50	1:20									2	13	31	40	88:00
120	60	1:20									8	23	34	110	177:00
120	70	1:20									16	31	34	170	253:00
120	80	1:10								3	26	31	46	220	328:00
120	90	1:10								11	28	31	96	281	449:00
120	100	1:10								19	28	31	140	347	567:00
120	120	1:00							5	27	28	66	187	500	815:00
120	180	1:00							24	32	97	162	409	741	1467:00
120	240	0:50						6	38	87	143	327	582	749	1934:00
120	360	0:50						31	110	146	358	537	636	749	2569:00
120	480	0:50						89	139	321	475	553	637	748	2964:00
120	720	0:40					28	179	332	438	489	553	636	749	3406:00
130	18	2:10												0	2:10

TBLP1 VVAL55 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
													DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)		
130	20	2:00												6	8:10
130	25	1:50											3	15	20:10
130	30	1:50											13	25	40:10
130	40	1:40										14	19	39	74:10
130	50	1:30									10	15	34	78	134:10
130	60	1:20								4	13	29	34	150	232:10
130	70	1:20								9	22	31	36	220	320:10
130	80	1:20								16	28	31	90	274	441:10
limit line															
130	90	1:10							2	29	28	31	141	351	580:10
140	16	2:20												0	2:20
140	20	2:10												11	13:20
140	25	2:00											10	18	30:20
140	30	1:50										5	15	29	51:20
140	40	1:40									[illegible]	13	25	38	86:20
140	50	1:30								5	13	21	24	117	192:20
140	60	1:30								10	16	32	34	194	290:20
140	70	1:20							5	1[illegible]	[illegible]	32	76	256	40[illegible]:[illegible]0
140	80	1:20							9	2[illegible]	28	71	1[illegible]	743	570:20
limit line															
140	90	1:20							16	26	28	46	1[illegible]	4[illegible]	[illegible]
140	120	1:10						14	24	26	39	157	[illegible]	670	[illegible]:20
140	180	1:00					11	23	30	83	144	254	585	[illegible]	[illegible]
140	240	1:00					18	39	84	129	[illegible]	462	636	749	[illegible]
140	360	0:50				9	53	106	137	32[illegible]	45[illegible]	554	636	749	3[illegible]
140	480	0:50				30	98	157	294	42[illegible]	[illegible]	554	636	749	3437:[illegible]

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	B(M TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
140	720	0:50				88	211	327	397	438	489	554	636	749	3891:20
150	14	2:30												0	2:30
150	15	2:20												1	3:30
150	20	2:10											2	15	19:30
150	25	2:00										1	15	22	40:30
150	30	2:00										13	14	33	62:30
150	40	1:40								2	13	14	29	64	124:30
150	50	1:30							1	12	13	25	34	155	242:30
150	60	1:30							8	13	21	31	53	222	350:30
150	70	1:20						2	11	18	28	31	118	319	529:30
150	80	1:20						5	14	26	28	35	177	404	691:30
160	12	2:40												0	2:40
160	15	2:30												5	7:40
160	20	2:20											7	16	25:40
160	25	2:10										7	15	25	49:40
160	30	2:00									5	14	14	38	73:40
160	40	1:50								9	13	14	34	97	169:40
160	50	1:40							8	13	13	30	34	196	296:40
160	60	1:30						4	12	12	27	31	91	273	452:40
limit line----															
160	70	1:30						10	12	22	28	31	162	374	641:40
170	10	2:50												0	2:50
170	15	2:30											2	8	12:50
170	20	2:20										2	11	16	31:50
170	25	2:20										14	14	28	58:50

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
170	30	2:10									12	13	18	38	83:50
170	40	1:50							4	12	13	18	34	132	215:50
170	50	1:40						4	12	12	17	31	50	221	349:50
170	60	1:30					1	11	12	15	28	31	130	333	563:50
limit line															
170	70	1:30					6	12	13	26	28	48	187	455	777:50
170	90	1:20				2	11	20	24	26	37	153	274	671	1220:50
170	120	1:20				14	21	22	25	44	144	203	518	748	1741:50
170	180	1:10			15	20	21	41	103	129	268	476	636	749	2460:50
170	240	1:00		4	19	30	52	106	117	276	418	553	636	749	2962:50
170	360	1:00		18	43	91	98	218	300	438	489	553	637	748	3635:50
170	480	1:00		46	85	113	241	311	397	438	489	553	636	749	4060:50
180	9	3:00												0	3:00
180	10	2:50												1	4:00
180	15	2:30										1	4	9	17:00
180	20	2:20									1	4	13	20	41:00
180	25	2:20									5	14	14	33	69:00
180	30	2:10								4	13	14	22	40	96:00
180	40	2:00							11	12	13	22	35	165	261:00
180	50	1:50						11	12	12	22	31	65	260	436:00
180	60	1:40					8	11	12	20	29	33	168	383	667:00
190	9	3:10												0	3:10
190	10	3:00												3	6:10
190	15	2:40										3	4	12	22:10
190	20	2:30									3	6	14	24	50:10

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)													
190	25	2:20									2	9	14	14	37	79:10
190	30	2:20									11	13	14	25	70	136:10
190	40	2:00							6	11	13	13	27	35	202	310:10
limit line																
190	50	1:50						7	11	12	12	27	31	120	317	540:10
190	60	1:40					5	10	12	11	25	29	52	187	465	799:10
limit line																
200	8	3:20													0	3:20
200	10	3:00												1	4	8:20
200	15	2:40										2	4	4	13	26:20
200	20	2:30									2	4	8	14	28	59:20
200	25	2:20								1	3	12	14	17	38	88:20
200	30	2:20								5	12	13	14	29	99	175:20
200	40	2:00						1	11	12	12	13	32	50	220	354:20
200	50	1:50					3	11	11	12	15	28	32	156	365	636:20
200	60	1:40				1	11	10	12	15	26	28	88	187	557	938:20
200	90	1:30			5	10	12	21	22	24	38	134	175	500	748	1692:20
200	120	1:30			14	19	19	21	23	57	129	154	410	634	749	2232:20
200	180	1:10	2	17	17	19	26	54	107	117	262	411	554	636	749	2976:20
200	240	1:10	10	16	25	36	82	98	121	287	380	489	554	636	749	3486:20
200	360	1:10	25	37	79	85	129	247	304	396	438	490	553	636	749	4171:20
limit line																
210	7	3:30													0	3:30
210	10	3:10												3	4	10:30
210	15	2:50										4	4	4	16	31:30
210	[illegible]	2:30								1	4	3	11	15	30	67:30
210	[illegible]	2:30								3	6	13	13	21	45	104:30

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
210	30	2:20						1	9	12	13	14	34	124	210:30
210	40	2:10					7	11	12	12	18	31	87	257	4[illegible]9.30
210	50	2:00				9	11	11	12	19	29	40	183	419	736.30
limit line															
220	7	3:40												0	3:40
220	10	3:10										1	4	4	12:40
220	15	2:50								3	3	4	7	14	34.40
220	20	2:40							4	3	4	13	15	34	76:40
220	25	2:30						3	3	8	13	14	25	73	142:40
220	30	2:30						4	12	12	13	17	35	152	248:40
220	40	2:10				2	11	11	12	12	22	31	112	303	519.40
220	50	2:00			6	10	11	11	11	25	25	70	187	507	869.40
limit line															
230	6	3:50												0	3:50
230	10	3:20										3	4	4	14:50
230	15	2:50							1	4	3	4	10	21	46:50
230	20	2:40						3	3	3	7	13	16	38	86:50
230	25	2:30					2	3	3	12	13	17	30	98	177:50
230	30	2:30					3	6	12	12	13	22	24	187	28[illegible]:50
230	40	2:20				8	11	11	12	12	27	31	147	346	604.50
230	50	2:00		2	10	10	11	11	14	26	29	101	187	588	992:50
limit line															
240	6	4:00												0	4:00
240	10	3:[illegible]									1	4	4	4	17:00
240	15	3:00							3	4	4	7	12	26	5[illegible]:0[illegible]
240	20	[illegible]:40					2	3	3	4	[illegible]	1[illegible]	20	38	9[illegible]:00
240	25	[illegible]				1	3	3	5	13	17	17	31	123	21[illegible]:00

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM, ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
240	30	2:30									2	3	10	11	13	13	26	38	211	331:00
240	40	2:20								4	10	11	11	12	14	29	37	170	368	690:00
240	50	2:10							8	10	10	11	11	18	26	32	130	225	633	1118:00
limit line																				
250	6	4:10																	0	4:10
250	10	3:30														3	4	4	4	19:10
250	15	3:00											2	3	4	4	3	15	29	64:10
250	20	2:40									1	3	3	3	4	12	13	23	53	119:10
250	25	2:40									3	3	3	8	13	13	17	34	149	247:10
250	30	2:30								1	3	5	11	12	12	13	30	57	220	368:10
250	40	2:30								10	10	10	12	11	19	28	51	187	457	795:10
250	60	2:00					5	9	10	10	10	12	22	25	33	114	163	443	749	1609:10
250	90	1:40			3	8	9	9	14	18	20	21	31	85	129	217	445	636	749	2398:10
250	120	1:40			8	12	15	17	17	19	23	47	106	117	236	396	553	637	748	2955:10
250	180	1:20	1	14	14	15	15	20	34	66	91	98	200	294	432	489	553	637	749	3725:10
250	240	1:20	9	14	14	22	31	58	79	84	124	247	300	397	438	489	554	636	749	4249:10
limit line																				
260	5	4:20																	0	4:20
260	10	3:30													1	4	4	4	15	32:20
260	15	3:00										1	3	3	4	4	6	14	33	72:20
260	20	2:50									3	3	3	3	5	13	14	27	75	150:20
260	25	2:40								2	3	3	4	11	12	13	21	34	178	285:20
260	30	2:30							1	2	3	8	11	12	12	16	31	84	252	436:20
260	40	2:30							5	10	10	11	11	12	22	29	79	186	528	907:20
limit line																				
270	5	4:30																	0	4:30
270	10	3:40													3	3	4	4	8	26:30

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)													
270	15	3:10						3	3	3	4	4	8	15	36	80:30
270	20	2:50				2	3	3	3	3	[illegible]	13	14	31	[illegible]	183:30
270	25	2:40			2	2	3	3	6	12	12	13	25	37	204	323:30
270	30	2:40			3	3	3	10	11	12	12	20	31	110	299	517:30
270	40	2:30		1	10	9	11	10	12	12	26	28	107	188	597	1015:30
limit line																
280	5	4:40													0	4:40
280	10	3:40								2	3	4	4	8	22	47:40
280	15	3:10					2	3	3	3	4	3	12	18	36	88:40
280	20	2:50			1	3	3	3	3	3	11	13	14	34	123	215:40
280	25	2:40		1	3	2	3	3	9	12	12	13	29	49	219	359:40
280	30	2:40		2	3	3	5	11	11	12	12	24	32	136	337	592:40
280	40	2:40		6	10	10	10	11	11	16	26	33	131	227	634	1129:40
limit line																
290	5	4:50													0	4:50
290	10	3:50								2	4	3	4	4	12	33:50
290	15	3:10				1	2	4	3	3	4	3	14	20	38	96:50
290	20	3:00			3	3	3	3	3	4	13	13	17	35	147	248:50
290	25	2:50		3	3	2	3	4	11	11	13	15	31	73	234	407:50
290	30	2:40	1	3	3	3	8	11	11	12	12	28	35	160	371	662:50
290	40	2:40	3	9	9	10	10	11	11	20	26	41	151	269	665	1239:50
limit line																
300	5	5:00													0	5:00
300	10	3:50							2	3	4	3	4	13	28	62:00
300	15	3:20				2	3	3	4	3	3	6	14	23	39	105:00
300	20	3:00		2	3	3	3	3	3	7	12	13	22	35	172	283:00
300	25	2:50	2	3	3	2	3	6	12	11	13	18	32	98	279	487:00

TBLP1 VVAL59 (FEET)

21.00% FIXED FO2 IN NITROGEN

RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (MIN)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 210	200	190	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
300	30	1:10								1	2	3	3	4	10	11	11	12	16	28	42	182	417	747:00
300	40	2:40								2	6	9	9	10	10	11	11	24	26	57	162	311	695	1348:00
300	60	2:10					1	8	8	9	9	9	10	10	20	21	22	49	123	144	391	621	748	2212:00
300	90	1:50			4	7	7	7	9	[illegible]	15	17	13	13	28	57	106	117	262	410	553	637	749	3073:00
300	120	1:40		3	7	6	10	13	14	15	16	17	16	41	91	99	128	234	388	493	553	636	749	3599:00
300	190	1:30	7	10	12	11	13	13	16	22	35	74	90	94	168	248	325	397	439	489	554	636	749	4392:00

TABLES IN METERS

TBLP1

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL59- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
3 MSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
6 MSW	136.513	124.513	86.843	71.353	64.643	61.543	60.513	60.263	60.017
9 MSW	146.355	134.355	96.685	81.195	74.465	71.385	70.355	70.105	[illegible]
12 MSW	156.198	144.198	106.528	91.038	84.328	81.228	80.198	79.948	[illegible]
15 MSW	166.040	154.040	116.370	100.880	94.170	91.070	90.040	89.790	89.540
18 MSW	175.883	163.883	126.213	110.723	104.013	100.913	99.883	99.633	99.383
21 MSW	185.725	173.725	136.055	120.565	113.855	110.755	109.725	109.475	109.225
24 MSW	195.568	183.568	145.898	130.408	123.698	120.598	119.568	119.318	119.068
27 MSW	205.410	193.410	155.740	140.250	133.540	130.440	129.410	129.160	128.910
30 MSW	215.253	203.253	165.583	150.093	143.383	140.283	139.253	139.003	138.753
33 MSW	225.095	213.095	175.425	159.935	153.225	150.125	149.095	148.845	148.595
36 MSW	234.938	222.938	185.268	169.778	163.068	159.968	158.938	158.688	158.438
39 MSW	244.780	232.780	195.110	179.620	172.910	169.810	168.780	168.530	168.280
42 MSW	254.623	242.623	204.953	189.463	182.753	179.653	178.623	178.373	178.123
45 MSW	264.465	252.465	214.795	199.305	192.595	189.495	188.465	188.215	187.965
48 MSW	274.308	262.308	224.638	209.148	202.438	199.338	198.308	198.058	197.808
51 MSW	284.150	272.150	234.480	218.990	212.280	209.180	208.150	207.900	207.650
54 MSW	293.993	281.993	244.323	228.833	222.123	219.023	217.993	217.743	217.493
57 MSW	303.836	291.836	254.165	238.675	231.965	228.865	227.835	227.585	227.335
60 MSW	313.678	301.678	264.008	248.518	241.808	238.708	237.678	237.428	237.178
63 MSW	323.521	311.521	273.850	258.360	251.650	248.550	247.520	247.270	247.020
66 MSW	333.363	321.363	283.693	268.203	261.493	258.393	257.363	257.113	256.863
69 MSW	343.206	331.206	293.536	278.046	271.336	268.236	267.206	266.956	266.706
72 MSW	353.048	341.048	303.378	287.888	281.178	278.078	277.048	276.798	276.548
75 MSW	362.891	350.891	313.221	297.731	291.021	287.921	286.891	286.641	286.391
78 MSW	372.733	360.733	323.063	307.573	300.863	297.763	296.733	296.483	296.233
81 MSW	382.576	370.576	332.906	317.416	310.706	307.606	306.576	306.326	306.076
84 MSW	392.418	380.418	342.748	327.258	320.548	317.448	316.418	316.168	315.918
87 MSW	402.261	390.261	352.591	337.101	330.391	327.291	326.261	326.011	325.761
90 MSW	412.103	400.103	362.433	346.943	340.233	337.133	336.103	335.853	335.603

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
12	173	0:40												0	0:40
12	200	0:30												12	12:40
12	210	0:30												16	16:40
12	230	0:30												38	38:40
12	250	0:30												56	56:40
12	270	0:30												73	73:40
12	300	0:30												95	95:40
limit line															
12	360	0:30												152	152:40
12	480	0:30												303	303:40
12	720	0:30												580	580:40
15	92	0:50												0	0:50
15	100	0:40												4	4:50
15	110	0:40												8	8:50
15	120	0:40												11	11:50
15	140	0:40												26	26:50
15	160	0:40												50	50:50
15	180	0:40												65	85:50
15	200	0:40												116	116:50
15	220	0:40												144	144:50
15	240	0:30											1	170	171:50
18	63	1:00												0	1:00
18	70	0:50												6	7:00
18	80	0:50												14	15:00
18	100	0:50												26	27:00

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
18	120	0:40											1	48	50:00
18	140	0:40											6	95	10[illegible]:00
18	160	0:40											9	138	149:00
18	180	0:40											21	166	188:00
18	200	0:40											32	204	237:00
18	240	0:40											74	300	375:00
18	360	0:30										6	195	579	781:00
18	480	0:30										49	342	717	1109:00
18	720	0:30										144	576	739	1460:00
21	48	1:10												0	1:10
21	50	1:00												2	3:10
21	60	1:00												14	15:10
21	70	1:00												25	26:10
21	80	1:00												34	35:10
21	90	0:50											7	37	45:10
21	100	0:50											17	49	67:10
21	110	0:50											17	80	98:10
21	120	0:50											21	108	130:10
21	130	0:50											25	133	159:10
21	140	0:50											31	154	186:10
21	150	0:50											41	171	213:10
21	160	0:40										2	46	194	243:10
21	170	0:40										3	55	220	279:10
24	40	1:20												0	1:20

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
24	50	1:10												17	18:20
24	60	1:10												31	32:20
24	70	1:00											9	33	43:20
24	80	1:00											18	39	58:20
24	90	1:00											26	65	92:20
24	100	0:50										2	30	100	133:20
24	110	0:50										7	30	134	172:20
24	120	0:50										11	35	161	208:20
24	130	0:50										14	44	183	242:20
24	140	0:50										17	52	216	286:20
24	150	0:50										20	74	240	335:20
limit line	-------														
24	180	0:50										35	127	359	522:20
24	240	0:40									5	88	197	592	883:20
24	360	0:40									55	177	471	739	1443:20
24	480	0:40									111	335	610	739	1796:20
24	720	0:30								13	279	531	629	739	2192:20
27	32	1:30												0	1:30
27	40	1:20												13	14:30
27	50	1:10											2	30	33:30
27	60	1:10											13	34	48:30
27	70	1:10											26	37	64:30
27	80	1:00										5	30	74	110:30
27	90	1:00										13	30	116	160:30
27	100	1:00										20	30	154	205:30

TBLF1 VVAL18 (METER)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
27	110	1:00										25	39	182	247:30
27	120	0:50									2	28	50	216	297:30
27	130	0:50									6	27	80	248	362:30
30	27	1:40												0	1:40
30	30	1:30												5	6:40
30	40	1:20											2	24	27:40
30	50	1:20											13	33	47:40
30	60	1:10										2	27	33	63:40
30	70	1:10										11	30	72	114:40
30	80	1:10										21	30	119	171:40
30	90	1:00									3	27	30	164	225:40
30	100	1:00									9	27	43	197	277:40
30	110	1:00									15	27	71	229	343:40
30	120	1:00									20	27	103	289	440:40
limit line															
30	180	0:50								10	35	103	212	604	965:40
30	240	0:50								25	82	159	418	727	1412:40
30	360	0:40							6	90	161	392	627	738	2015:40
30	480	0:40							33	141	323	527	629	739	2393:40
30	720	0:40							97	317	485	548	629	739	2816:40
33	23	1:50												0	1:50
33	25	1:40												3	4:50
33	30	1:40												13	14:50
33	40	1:30											11	27	39:50
33	50	1:20										6	20	33	60:50

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
33	60	1:20										13	30	57	101:50
33	70	1:10									3	23	30	114	171:50
33	80	1:10									9	28	30	165	233:50
33	90	1:10									18	27	44	207	297:50
33	100	1:00								1	24	28	81	250	385:50
36	20	2:00												0	2:00
36	25	1:50												11	13:00
36	30	1:40											5	17	24:00
36	40	1:30										5	14	31	52:00
36	50	1:20									1	13	25	37	78:00
36	60	1:20									7	19	30	98	156:00
36	70	1:20									13	27	30	155	227:00
36	80	1:10								2	22	27	42	206	301:00
36	90	1:10								8	25	27	86	259	407:00
36	100	1:10								15	25	29	126	331	528:00
36	120	1:00							4	23	24	59	175	472	759:00
36	150	1:00							20	34	84	153	405	719	1417:00
36	240	0:50						5	37	76	135	326	565	738	1884:00
36	360	0:50						29	99	151	348	525	629	739	2522:00
36	480	0:50						80	141	313	466	547	630	739	2918:00
36	720	0:40					23	174	325	435	485	548	629	739	3360:00
39	16	2:10												0	2:10
39	20	2:00												4	6:10
39	25	1:50											2	15	19:10

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
39	30	1:50											12	[illegible]	[illegible]
39	40	1:40										13	15	[illegible]	[illegible]
39	50	1:30									9	13	26	69	121:10
39	60	1:20								3	13	23	70	136	[illegible]
39	70	1:20								8	18	[illegible]	40	[illegible]	[illegible]
39	80	1:20								13	25	27	[illegible]	[illegible]	[illegible]
limit line															
39	90	1:10							1	21	25	[illegible]	[illegible]	[illegible]	[illegible]
42	16	2:20												[illegible]	[illegible]
42	20	2:10												10	12:20
42	25	2:00											5	17	[illegible]
42	30	1:50										4	14	[illegible]	44:20
42	40	1:40									7	13	19	36	77:20
42	50	1:30								4	13	15	70	104	168:20
42	60	1:30								11	13	27	32	175	260:20
42	70	1:20							4	12	23	27	68	227	363:20
42	80	1:20							8	18	25	27	123	323	526:20
limit line															
42	90	1:20							13	[illegible]	24	[illegible]	160	401	665:20
42	120	1:10						11	21	27	44	132	265	643	1141:20
42	180	1:00					9	20	33	70	135	280	546	739	1834:20
42	240	1:00					15	40	74	120	[illegible]	447	629	733	2317:20
42	360	0:50				7	48	99	143	315	416	[illegible]	630	734	2976:20
42	480	0:50				25	92	156	232	419	495	547	630	739	3387:20
42	720	0:50				63	207	322	394	434	[illegible]	[illegible]	[illegible]	[illegible]	3647:20
45	15	2:30												6	[illegible]

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
45	20	2:10											1	15	18:30
45	25	2:10											15	16	33:30
45	30	2:00										11	15	24	52:30
45	40	1:40								1	12	14	22	54	105:30
45	50	1:40								12	13	18	30	141	216:30
45	60	1:30							7	12	16	27	46	211	321:30
45	70	1:20						1	11	14	25	27	106	296	482:30
45	80	1:20						4	12	22	25	39	152	386	642:30
48	12	2:40												0	2:40
48	15	2:30												4	6:40
48	20	2:20											6	15	23:40
48	25	2:10										6	14	20	42:40
48	30	2:00									4	13	15	28	62:40
48	40	1:50								8	13	14	24	88	149:40
48	50	1:40							7	13	12	22	36	174	266:40
48	60	1:30						3	12	12	20	27	82	249	407:40
limit line															
48	70	1:30						9	11	17	25	35	139	358	596:40
51	11	2:50												0	2:50
51	15	2:30											1	7	10:50
51	20	2:20										1	11	15	29:50
51	25	2:20										12	15	20	49:50
51	30	2:10									11	13	14	31	71:50
51	40	1:50							3	12	13	13	29	118	190:50
51	50	1:40						3	12	12	13	25	47	206	320:50

TBLP1 VVAL59 (METERS)

21.00% FIXED PO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
51	60	1:40						11	12	12	22	28	117	310	514:50
limit line															
51	70	1:30					5	12	11	21	24	48	167	420	710:50
51	90	1:20				1	11	16	21	23	42	131	260	639	1146:50
51	120	1:20				11	19	19	22	46	125	190	494	736	1665:50
51	180	1:10			13	17	20	44	88	121	266	457	629	739	2396:50
51	240	1:00		3	16	32	43	100	119	268	404	548	629	739	2903:50
51	360	1:00		16	39	85	101	212	292	435	484	548	630	739	3593:50
51	480	1:00		41	79	118	235	304	394	435	484	548	630	739	4009:50
54	10	3:00												0	3:00
54	15	2:40											4	9	16:00
54	20	2:30										4	13	15	35:00
54	25	2:20									4	14	14	24	59:00
54	30	2:10								3	13	14	14	47	89:00
54	40	2:00							10	12	13	15	30	151	234:00
54	50	1:50						10	12	12	14	28	76	235	390:00
54	60	1:40					7	11	12	14	24	39	144	367	621:00
57	9	3:10												0	3:10
57	10	3:00												2	5:10
57	15	2:40										2	4	11	20:10
57	20	2:30									3	5	14	17	42:10
57	25	2:20								1	9	13	15	26	67:10
57	30	2:20								10	13	13	18	61	118:10
57	40	2:00						5	11	12	13	19	39	176	278:10
limit line															
57	50	1:50					6	11	12	12	18	27	110	294	493:10

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)													
57	60	1:40					4	10	12	11	17	25	51	169	428	730:10
limit line																
60	8	3:20													0	3:20
60	10	3:10													4	7:20
60	15	2:40										1	4	4	13	25:20
60	20	2:30									2	3	8	14	20	50:20
60	25	2:30									4	11	14	14	32	78:20
60	30	2:20								3	12	13	14	20	87	152:20
60	40	2:10							11	12	12	13	21	49	205	326:20
60	50	1:50					2	11	11	11	13	21	36	135	348	591:20
60	60	1:50					11	10	12	11	20	25	79	175	516	862:20
60	90	1:30			4	10	10	17	20	21	44	111	173	459	739	1611:20
60	120	1:30			11	17	17	19	24	48	120	154	388	610	739	2150:20
60	180	1:10	1	15	15	16	33	44	99	111	258	393	548	630	738	2904:20
60	240	1:10	8	14	27	36	70	92	131	274	369	485	548	629	739	3425:20
60	360	1:10	24	32	74	80	131	246	295	394	434	485	548	629	739	4114:20
limit line																
63	7	3:30													0	3:30
63	10	3:10												2	4	9:30
63	15	2:50										3	4	4	15	29:30
63	20	2:30								1	3	4	10	14	23	58:30
63	25	2:30								3	5	12	14	14	43	94:30
63	30	2:20							1	8	12	13	13	24	115	189:30
63	40	2:10						6	11	12	12	13	25	74	228	384:30
63	50	2:00					9	10	11	12	12	25	46	158	396	682:30
limit line																
66	[illegible]	3:40													0	3:40

TBLF1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
66	10	3:20											4	4	11:40
66	15	2:50								2	4	3	7	15	34:40
66	20	2:40							3	4	3	13	14	25	65:40
66	25	2:30						2	3	8	13	13	17	63	122:40
66	30	2:30						3	12	12	13	13	27	140	223:40
66	40	2:10				2	10	11	12	12	14	27	103	275	477:40
66	50	2:00			5	10	11	11	11	16	25	63	174	469	798:40
limit line															
69	7	3:50												0	3:50
69	10	3:20										2	4	4	13:50
69	15	2:50							1	3	4	4	8	17	40:50
69	20	2:40						2	3	4	5	14	14	28	73:50
69	25	2:30					1	3	4	10	13	14	19	88	155:50
69	30	2:30					2	6	12	12	13	13	36	161	258:50
69	40	2:20				7	11	11	12	12	17	35	124	336	56[illegible]:50
69	50	2:00		1	10	10	11	11	11	13	29	88	182	544	919:50
limit line															
72	6	4:00												0	4:00
72	10	3:30										4	4	4	16:00
72	15	3:00							3	3	4	4	11	19	48:00
72	20	2:40					1	3	4	3	8	14	14	36	87:00
72	25	2:40					3	4	4	12	13	14	23	111	188:00
72	30	2:30				1	4	9	11	12	13	17	43	183	297:00
72	40	2:20			3	10	11	11	11	13	20	43	146	374	646:00
72	50	2:10		7	10	10	11	11	11	22	38	109	207	602	1042:00
limit line															
75	6	4:10												0	4:10

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)																	
75	10	3:30														2	4	4	4	18:10
75	15	3:00											2	3	3	4	4	13	22	55:10
75	20	2:50										3	3	4	3	11	13	16	44	101:10
75	25	2:40									3	3	3	7	13	12	14	27	136	222:10
75	30	2:30								1	3	4	11	11	13	12	20	52	210	341:10
75	40	2:30								9	10	10	12	11	12	24	52	166	419	729:10
75	60	2:00					5	9	9	10	10	10	16	21	40	95	158	418	723	1528:10
75	90	1:40			2	9	8	9	10	15	17	19	38	67	120	201	419	629	739	2306:10
75	120	1:40			7	9	14	15	15	17	28	41	92	110	223	374	548	629	739	2865:10
75	160	1:30		12	13	13	14	24	33	54	86	93	195	292	415	485	543	629	739	3649:10
75	240	1:20	7	12	13	25	31	47	75	79	127	243	288	394	435	485	548	629	739	4181:10
limit line																				
78	5	4:20																	0	4:20
78	10	3:40														4	4	4	4	20:20
78	15	3:10											4	3	3	4	5	14	25	62:20
78	20	2:50									2	3	3	4	4	13	13	18	65	129:20
78	25	2:40								2	3	3	3	11	12	12	14	34	157	255:20
78	30	2:40								3	3	7	11	11	13	12	24	75	227	390:20
78	40	2:30							4	10	10	11	11	12	13	25	71	175	488	834:20
limit line																				
81	5	4:30																	0	4:30
81	10	3:40													2	4	3	4	7	24:30
81	15	3:10										2	3	4	3	4	7	15	27	69:30
81	20	2:50								1	3	3	4	3	7	12	14	22	88	161:30
81	25	2:40							1	3	3	3	5	11	13	12	17	41	177	290:30
81	30	2:40							2	3	3	10	11	12	12	12	27	99	272	467:30

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	57	54	51	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)																			
81	40	2:30								1	9	10	10	10	11	12	17	31	92	186	554	947:30
limit line																						
84	5	4:40																			0	4:40
84	10	3:50															4	3	4	4	8	27:40
84	15	3:10											1	3	3	4	3	4	10	14	30	76:40
84	20	2:50									1	2	3	3	3	4	9	13	14	24	110	190:40
84	25	2:50									3	3	3	3	8	11	12	13	20	49	199	327:40
84	30	2:40								2	2	3	5	11	11	12	12	15	33	119	317	546:40
84	40	2:40								6	9	10	10	10	12	11	20	40	109	211	603	1055:40
limit line																						
87	5	4:50																			0	4:50
87	10	3:50														2	3	4	4	3	11	31:50
87	15	3:20											3	3	3	3	4	4	12	14	33	83:50
87	20	3:00									2	3	3	3	3	4	12	13	13	27	132	219:50
87	25	2:50								2	3	3	3	3	10	12	12	13	22	64	221	372:50
87	30	2:40							1	3	2	3	8	11	11	12	12	18	41	137	359	621:50
87	40	2:40							3	8	9	10	10	11	11	11	23	48	127	254	632	1161:50
limit line																						
90	5	5:00																			0	5:00
90	10	4:00														3	4	3	4	4	12	35:00
90	15	3:20										2	3	3	3	3	4	5	13	17	40	98:00
90	20	3:00								2	2	3	3	3	3	7	12	12	15	31	154	252:00
90	25	2:50							2	2	3	3	3	5	11	12	12	13	25	88	252	436:00
90	30	2:50							3	3	2	4	10	11	11	11	13	20	49	155	395	692:00
90	40	2:40						2	5	9	9	10	10	11	11	14	23	57	145	295	662	1268:00
90	60	2:10			1	7	8	8	9	9	9	10	12	18	27	47	109	145	366	595	739	2124:00
90	90	1:50	3	7	7	7	8	9	9	14	16	16	35	42	100	109	244	386	547	630	739	2933:00

TBLP1 VVAL59 (METERS)

21.00% FIXED FO2 IN NITROGEN

RATES: DESCENT 18 MPM; ASCENT 18 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	63	60	57	54	5	48	45	42	39	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)																					
90	120	1:40		2	7	6	7	11	13	13	14	15	32	36	76	92	129	274	367	484	548	630	738	3499:00
90	120	1:30	5	9	10	10	11	12	20	28	30	65	74	84	158	246	309	394	435	485	548	629	739	4306:00

APPENDIX G

0.7 ATA PO_2 in N_2

Tables in feet with 10 FSW Stop Depth Increment and in meters with 3 MSW Stop Depth Increments

MPTT Tables are included for reference in FSW and MSW.

TABLES IN FEET

TBLP1

TARLE OF MAXIMUM PEPMISSIBLE TISSUE TENSIONS

(VVAL59- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .85 SDR	80 MIN .96 SDR	120 MIN .68 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
10 FSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
20 FSW	136.670	124.670	87.000	71.510	64.800	61.700	60.670	60.420	60.170
30 FSW	146.670	134.670	97.000	81.510	74.800	71.700	70.670	70.420	70.170
40 FSW	156.670	144.670	107.000	91.510	84.800	81.700	80.670	80.420	80.170
50 FSW	166.670	154.670	117.000	101.510	94.800	91.700	90.670	90.420	90.170
60 FSW	176.670	164.670	127.000	111.510	104.800	101.700	100.670	100.420	100.170
70 FSW	186.670	174.670	137.000	121.510	114.800	111.700	110.670	110.420	110.170
80 FSW	196.670	184.670	147.000	131.510	124.800	121.700	120.670	120.420	120.170
90 FSW	206.670	194.670	157.000	141.510	134.800	131.700	130.670	130.420	130.170
100 FSW	216.670	204.670	167.000	151.510	144.800	141.700	140.670	140.420	140.170
110 FSW	226.670	214.670	177.000	161.510	154.800	151.700	150.670	150.420	150.170
120 FSW	236.670	224.670	187.000	171.510	164.800	161.700	160.670	160.420	160.170
130 FSW	246.670	234.670	197.000	181.510	174.800	171.700	170.670	170.420	170.170
140 FSW	256.670	244.670	207.000	191.510	184.800	181.700	180.670	180.420	180.170
150 FSW	266.670	254.670	217.000	201.510	194.800	191.700	190.670	190.420	190.170
160 FSW	276.670	264.670	227.000	211.510	204.800	201.700	200.670	200.420	200.170
170 FSW	286.670	274.670	237.000	221.510	214.800	211.700	210.670	210.420	210.170
180 FSW	296.670	284.670	247.000	231.510	224.800	221.700	220.670	220.420	220.170
190 FSW	306.670	294.670	257.000	241.510	234.800	231.700	230.670	230.420	230.170
200 FSW	316.670	304.670	267.000	251.510	244.800	241.700	240.670	240.420	240.170
210 FSW	326.670	314.670	277.000	261.510	254.800	251.700	250.670	250.420	250.170
220 FSW	336.670	324.670	287.000	271.510	264.800	261.700	260.670	260.420	260.170
230 FSW	346.670	334.670	297.000	281.510	274.800	271.700	270.670	270.420	270.170
240 FSW	356.670	344.670	307.000	291.510	284.800	281.700	280.670	280.420	280.170
250 FSW	366.670	354.670	317.000	301.510	294.800	291.700	290.670	290.420	290.170
260 FSW	376.670	364.670	327.000	311.510	304.800	301.700	300.670	300.420	300.170
270 FSW	386.670	374.670	337.000	321.510	314.800	311.700	310.670	310.420	310.170
280 FSW	396.670	384.670	347.000	331.510	324.800	321.700	320.670	320.420	320.170
290 FSW	406.670	394.670	357.000	341.510	334.800	331.700	330.670	330.420	330.170
300 FSW	416.670	404.670	367.000	351.510	344.800	341.700	340.670	340.420	340.170

BLOOD PARAMETERS

(PRESSURE IN FSW; 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
FVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
FFOVP	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
40	363	0:40												0	0:40
limit line															
40	370	0:30												1	1:40
40	380	0:30												3	3:40
40	390	0:30												4	4:40
50	141	0:50												0	0:50
50	150	0:40												3	3:50
50	160	0:40												6	6:50
50	170	0:40												9	9:50
50	180	0:40												12	12:50
50	190	0:40												17	17:50
50	200	0:40												24	24:50
50	210	0:40												29	29:50
50	220	0:40												35	35:50
50	230	0:40												40	40:50
50	240	0:40												45	45:50
50	250	0:40												50	50:50
50	260	0:40												54	54:50
50	270	0:40												59	59:50
50	280	0:40												63	63:50
50	290	0:40												67	67:50
50	300	0:40												73	73:50
50	310	0:40												79	79:50
50	320	0:40												84	84:50
50	330	0:40												89	89:50

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
limit line															
50	340	0:40												98	98:50
50	350	0:40												107	107:50
50	360	0:40												115	115:50
50	370	0:40												123	123:50
50	380	0:40												131	131:50
50	390	0:40												139	139:50
60	70	1:00												0	1:00
60	80	0:50												5	6:00
60	90	0:50												8	9:00
60	100	0:50												11	12:00
60	110	0:50												14	15:00
60	120	0:50												19	20:00
60	130	0:50												24	25:00
60	140	0:50												35	36:00
60	150	0:50												46	47:00
60	160	0:40											1	55	57:00
60	170	0:40											2	64	67:00
60	180	0:40											3	72	76:00
60	190	0:40											6	78	85:00
60	200	0:40											9	83	93:00
60	210	0:40											12	88	101:00
60	220	0:40											14	96	111:00
60	230	0:40											16	104	121:00
60	240	0:40											20	116	137:00

TBLP1 VVAL59 (FEET)

70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM, ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
60	250	0:40											26	127	154:00
60	260	0:40											32	137	170:00
60	270	0:40											38	146	185:00
60	280	0:40											43	156	200:00
limit	line	------													
60	290	0:40											48	164	213:00
60	300	0:40											52	173	226:00
60	310	0:40											56	182	239:00
60	320	0:40											61	192	254:00
60	330	0:40											64	204	269:00
60	340	0:40											68	216	285:00
60	350	0:40											71	228	300:00
60	360	0:40											75	239	315:00
60	370	0:40											78	250	329:00
60	380	0:40											84	258	343:00
60	390	0:40											89	266	356:00
70	49	1:10												0	1:10
70	50	1:00												1	2:10
70	60	1:00												9	10:10
70	70	1:00												15	16:10
70	80	1:00												21	22:10
70	90	0:50											4	21	26:10
70	100	0:50											8	23	32:10
70	110	0:50											11	36	48:10
70	120	0:50											14	49	64:10

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
70	130	0:50											16	61	78:10
70	140	0:50											18	73	92:10
70	150	0:50											22	82	105:10
70	160	0:50											27	89	117:10
70	170	0:40										1	31	97	130:10
limit line															
70	180	0:40										2	38	107	148:10
70	190	0:40										2	48	122	173:10
70	200	0:40										3	57	136	197:10
70	210	0:40										5	65	149	220:10
70	220	0:40										8	71	162	242:10
70	230	0:40										11	76	175	263:10
70	240	0:40										13	82	186	282:10
70	250	0:40										15	88	201	305:10
70	260	0:40										18	92	219	330:10
70	270	0:40										20	96	235	352:10
70	280	0:40										23	100	251	375:10
70	290	0:40										29	104	264	398:10
70	300	0:40										34	109	277	421:10
70	310	0:40										40	116	286	443:10
70	320	0:40										45	126	292	464:10
70	330	0:40										49	137	297	484:10
70	340	0:40										54	146	303	504:10
70	350	0:40										58	156	308	523:10
80	30	1:20												0	1:20

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (FSW) STOP TIMES (MIN)												
80	40	1:10												2	3:20
80	50	1:10												13	14:20
80	60	1:00											1	21	23:20
80	70	1:00											9	21	31:20
80	80	1:00											15	22	38:20
80	90	1:00											21	33	55:20
limit line															
80	100	0:50										4	21	51	77:20
80	110	0:50										8	21	67	97:20
80	120	0:50										11	21	82	115:20
80	130	0:50										14	25	93	133:20
80	140	0:50										16	32	101	150:20
80	150	0:50										18	46	115	180:20
80	160	0:50										19	59	133	212:20
80	170	0:50										27	69	150	247:20
80	180	0:40									1	26	77	167	272:20
80	190	0:40									2	30	85	183	301:20
80	200	0:40									2	34	93	197	327:20
80	210	0:40									3	37	100	219	360:20
80	220	0:40									4	47	100	242	394:20
80	230	0:40									5	57	101	264	427:20
80	240	0:40									8	62	109	279	459:20
80	250	0:40									11	68	124	287	491:20
80	260	0:40									13	74	135	[illegible]	[illegible]
80	270	0:40									15	87	151	[illegible]	549:20

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
80	280	0:40									18	85	164	309	577:20
80	290	0:40									20	90	176	316	603:20
80	300	0:40									21	96	188	323	629:20
80	310	0:40									23	100	200	329	653:20
80	320	0:40									29	100	213	335	678:20
90	29	1:30												0	1:30
90	30	1:20												1	2:30
90	40	1:20												13	14:30
90	50	1:10											5	20	26:30
90	60	1:10											15	21	37:30
90	70	1:00										2	22	21	46:30
limit line															
90	80	1:00										10	21	42	74:30
90	90	1:00										16	21	61	99:30
90	100	1:00										21	22	79	123:30
90	110	0:50									4	22	23	97	147:30
90	120	0:50									8	22	38	103	172:30
90	130	0:50									11	22	55	125	214:30
90	140	0:50									14	21	71	146	253:30
90	150	0:50									16	25	83	166	291:30
90	160	0:50									18	30	92	186	327:30
90	170	0:50									20	36	100	207	364:30
90	180	0:50									21	49	101	235	407:30
90	190	0:40								1	23	61	101	263	450:30
100	24	1:40												0	1:40

TBLF1 [illegible] FEET

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT [illegible] FPM ASCENT [illegible] FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	[illegible] ASCENT TIME (M:S)
100	25	1:30												2	3:40
100	30	1:30												8	9:40
100	35	1:20											2	13	16:40
100	40	1:20											7	16	24:40
100	45	1:20											10	21	32:40
100	50	1:10										3	13	22	39:40
100	55	1:10										5	18	21	45:40
100	60	1:10										7	21	22	51:40
100	65	1:10										12	22	30	65:40
limit line															
100	70	1:10										17	22	42	82:40
100	75	1:00									1	21	21	55	99:40
100	80	1:00									4	22	21	66	114:40
100	90	1:00									11	22	21	90	145:40
100	100	1:00									17	22	33	100	173:40
100	110	0:50								1	22	21	53	122	220:40
110	20	1:50												0	1:50
110	25	1:40												8	9:50
110	30	1:30											4	11	16:50
110	35	1:30											10	15	26:50
110	40	1:20										4	11	19	35:50
110	45	1:20										8	13	21	43:50
limit line															
110	50	1:20										11	18	21	51:50
110	55	1:10									3	11	22	24	61:50
110	60	1:10									6	15	21	40	83:50

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
110	65	1:10									8	19	21	53	102:50
110	70	1:10									11	21	21	67	121:50
110	80	1:00								2	18	22	21	93	157:50
110	90	1:00								7	21	22	40	105	196:50
120	17	2:00												0	2:00
120	20	1:50												5	7:00
120	25	1:40											3	11	16:00
120	30	1:40											11	12	25:00
120	35	1:30										6	11	17	36:00
120	40	1:20									1	11	11	22	47:00
limit line----															
120	45	1:20									5	11	16	22	56:00
120	50	1:20									9	11	21	29	72:00
120	55	1:10								2	11	14	22	46	97:00
120	60	1:10								4	11	19	22	61	119:00
120	70	1:10								9	16	22	21	92	162:00
120	80	1:00							1	14	21	22	43	108	211:00
130	15	2:10												0	2:10
130	20	2:00												10	12:10
130	25	1:50											9	11	22:10
130	30	1:40										7	11	14	34:10
130	35	1:30									3	11	11	19	46:10
130	40	1:30									9	11	14	21	57:10
limit line----															
130	45	1:20								3	11	11	19	31	77:10
130	50	1:20								7	11	14	21	50	105:10

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (FSW) STOP TIMES (MIN) 120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
130	60	1:10							3	11	13	21	22	84	156:10
130	70	1:10							8	11	21	22	40	105	209:10
140	12	2:20												0	2:20
140	15	2:10												3	5:20
140	20	2:00											4	11	17:20
140	25	1:50										4	11	12	29:20
140	30	1:40									3	11	10	17	43:20
limit line															
140	35	1:40									10	11	12	21	56:20
140	40	1:30								6	11	11	17	30	77:20
140	45	1:30								12	10	12	22	50	108:20
140	50	1:20							5	11	11	18	21	71	139:20
140	60	1:10						2	10	11	19	21	32	100	196:20
140	70	1:10						7	11	16	21	22	69	143	291:20
150	10	2:30												0	2:30
150	15	2:10											2	5	9:30
150	20	2:00										2	6	11	27:30
150	25	2:00										10	11	13	36:30
150	30	1:50									9	11	11	19	52:30
limit line															
150	35	1:40								7	11	11	14	24	69:30
150	40	1:30							3	11	11	11	20	48	106:30
150	45	1:30							9	11	11	16	21	71	141:30
150	50	1:20						3	11	11	11	[illegible]	21	93	174:30
150	60	1:20						11	11	11	[illegible]	21	56	128	264:30
150	70	1:10					6	11	11	[illegible]	22	24	46	178	321:30

TBLP1 VVAL59 (FEET)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 60 FPM; ASCENT 60 FPM

DEPTH (FSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	120	110	100	90	80	70	60	50	40	30	20	10	TOTAL ASCENT TIME (M:S)
limit line															
160	9	2:40												0	2:40
160	10	2:30												1	3:40
160	15	2:10										1	3	7	13:40
160	20	2:00									1	4	10	10	27:40
160	25	2:00									6	11	10	15	44:40
160	30	1:50								5	11	11	11	21	61:40
160	40	1:40							11	11	11	13	22	66	136:40
160	50	1:20					1	11	11	11	15	22	39	103	215:40
limit line															
170	8	2:50												0	2:50
170	10	2:40												3	5:50
170	15	2:10									1	3	3	8	17:50
170	20	2:00								1	3	5	11	11	33:50
170	25	2:00								3	9	11	10	18	53:50
170	30	1:50							1	11	11	11	13	27	76:50
170	40	1:40						8	11	11	11	17	22	86	168:50
170	50	1:30					10	11	11	11	20	21	64	136	286:50

TABLES IN METERS

TBLP1

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(VVAL59- NITROGEN)

TISSUE HALF-TIMES

DEPTH	5 MIN .40 SDR	10 MIN .50 SDR	20 MIN .55 SDR	40 MIN .96 SDR	80 MIN .96 SDR	120 MIN .72 SDR	160 MIN .60 SDR	200 MIN .45 SDR	240 MIN .40 SDR
3 MSW	126.670	114.670	77.000	61.510	54.800	51.700	50.670	50.420	50.170
6 MSW	136.513	124.513	86.843	71.353	64.643	61.543	60.513	60.263	60.013
9 MSW	146.355	134.355	96.685	81.195	74.485	71.385	70.355	70.105	69.855
12 MSW	156.198	144.198	106.528	91.038	84.328	81.228	80.198	79.948	79.698
15 MSW	166.040	154.040	116.370	100.880	94.170	91.070	90.040	89.790	89.540
18 MSW	175.883	163.883	126.213	110.723	104.013	100.913	99.883	99.633	99.383
21 MSW	185.725	173.725	136.055	120.565	113.855	110.755	109.725	109.475	109.225
24 MSW	195.568	183.568	145.898	130.408	123.698	120.598	119.568	119.318	119.068
27 MSW	205.410	193.410	155.740	140.250	133.540	130.440	129.410	129.160	128.910
30 MSW	215.253	203.253	165.583	150.093	143.383	140.283	139.253	139.003	138.753
33 MSW	225.095	213.095	175.425	159.935	153.225	150.125	149.095	148.845	148.595
36 MSW	234.938	222.938	185.268	169.778	163.068	159.968	158.938	158.688	158.438
39 MSW	244.780	232.780	195.110	179.620	172.910	169.810	168.780	168.530	168.280
42 MSW	254.623	242.623	204.953	189.463	182.753	179.653	178.623	178.373	178.123
45 MSW	264.465	252.465	214.795	199.305	192.595	189.495	188.465	188.215	187.965
48 MSW	274.308	262.308	224.638	209.148	202.438	199.338	198.308	198.058	197.808
51 MSW	284.150	272.150	234.480	218.990	212.280	209.180	208.150	207.900	207.650
54 MSW	293.993	281.993	244.323	228.833	222.123	219.023	217.993	217.743	217.493
57 MSW	303.836	291.836	254.165	238.675	231.965	228.865	227.835	227.585	227.335
60 MSW	313.678	301.678	264.008	248.518	241.808	238.708	237.678	237.428	237.178
63 MSW	323.521	311.521	273.850	258.360	251.650	249.550	247.520	247.270	247.020
66 MSW	333.363	321.363	283.693	268.203	261.493	258.393	257.363	257.113	256.863
69 MSW	343.206	331.206	293.536	278.046	271.336	268.236	267.206	266.956	266.706
72 MSW	353.048	341.048	303.378	287.888	281.178	278.078	277.048	276.798	276.548
75 MSW	362.891	350.891	313.221	297.731	291.021	287.921	286.891	286.641	286.391
78 MSW	372.733	360.733	323.063	307.573	300.863	297.763	296.733	296.483	296.233
81 MSW	382.576	370.576	332.906	317.416	310.706	307.606	306.576	306.326	306.076
84 MSW	392.418	380.418	342.748	327.258	320.548	317.448	316.418	316.168	315.918
87 MSW	402.261	390.261	352.591	337.101	330.391	327.291	326.261	326.011	325.761
90 MSW	412.103	400.103	362.433	346.943	340.233	337.133	336.103	335.853	335.603

BLOOD PARAMETERS

(PRESSURE IN FSW, 33 FSW ATA)

PACO2 (FSW)	PH2O (FSW)	DAAO2(VOL %)
1.70	2.00	.170

CAVO2	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	2.39	(VOL %)
PVCO2	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	1.87	(FSW)
PBOVP	36.00	36.00	29.00	13.00	10.00	7.00	7.00	7.00	7.00	(FSW)

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MFM; ASCENT 20 MFM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
12	370	0:36												0	0:36
15	149	0:45												0	0:45
15	150	0:36												1	1:45
15	160	0:36												4	4:45
15	170	0:36												6	6:45
15	180	0:36												9	9:45
15	190	0:36												11	11:45
15	200	0:36												17	17:45
15	210	0:36												23	23:45
15	220	0:36												28	28:45
15	230	0:36												33	33:45
15	240	0:36												37	37:45
15	250	0:36												42	42:45
15	260	0:36												46	46:45
15	270	0:36												50	50:45
15	280	0:36												53	53:45
15	290	0:36												58	58:45
15	300	0:36												64	64:45
15	310	0:36												70	70:45
15	320	0:36												75	75:45
15	330	0:36												80	80:45
limit line															
15	340	0:36												86	86:45
15	350	0:36												93	93:45
15	360	0:36												101	101:45

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
15	370	0:36												109	109:45
15	380	0:36												117	117:45
15	390	0:36												124	124:45
18	73	0:54												0	0:54
18	80	0:45												3	3:54
18	90	0:45												6	6:54
18	100	0:45												9	9:54
18	110	0:45												11	11:54
18	120	0:45												16	16:54
18	130	0:45												21	21:54
18	140	0:45												28	28:54
18	150	0:45												38	38:54
18	160	0:45												48	48:54
18	170	0:45												57	57:54
18	180	0:36											1	64	65:54
18	190	0:36											3	70	73:54
18	200	0:36											6	75	81:54
18	210	0:36											9	81	90:54
18	220	0:36											11	90	101:54
18	230	0:36											14	97	111:54
18	240	0:36											16	106	122:54
18	250	0:36											20	118	138:54
18	260	0:36											25	129	154:54
18	270	0:36											30	139	169:54

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
18	280	0:36											35	148	183:54
limit	line----														
18	290	0:36											39	158	197:54
18	300	0:36											43	167	210:54
18	310	0:36											47	175	222:54
18	320	0:36											51	183	234:54
18	330	0:36											55	193	248:54
18	340	0:36											58	205	263:54
18	350	0:36											61	217	278:54
18	360	0:36											64	228	292:54
18	370	0:36											69	237	306:54
18	380	0:36											75	245	320:54
18	390	0:36											80	253	333:54
21	51	1:03												0	1:03
21	60	0:54												6	7:03
21	70	0:54												12	13:03
21	80	0:54												17	18:03
21	90	0:45											2	19	22:03
21	100	0:45											5	23	29:03
21	110	0:45											8	31	40:03
21	120	0:45											11	43	55:03
21	130	0:45											13	54	68:03
21	140	0:45											14	66	81:03
21	150	0:45											19	73	93:03
21	160	0:45											24	80	105:03

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
21	170	0:45											29	90	120:03
limit line															
21	180	0:45											33	102	136:03
21	190	0:36										1	41	115	158:03
21	200	0:36										1	50	130	182:03
21	210	0:36										2	58	143	204:03
21	220	0:36										5	64	156	226:03
21	230	0:36										8	68	169	246:03
21	240	0:36										10	74	181	266:03
21	250	0:36										13	78	193	285:03
21	260	0:36										15	82	210	308:03
21	270	0:36										17	86	227	331:03
21	280	0:36										19	95	238	353:03
21	290	0:36										22	101	251	375:03
21	300	0:36										27	106	263	397:03
21	310	0:36										32	110	275	418:03
21	320	0:36										36	119	283	439:03
21	330	0:36										41	129	288	459:03
21	340	0:36										45	139	294	479:03
21	350	0:36										49	149	299	498:03
24	39	1:12												0	1:12
24	40	1:03												1	2:12
24	50	1:03												10	11:12
24	60	1:03												18	19:12
24	70	0:54											6	19	26:12

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
24	80	0:54											12	20	33:12
24	90	0:54											17	29	47:12
24	100	0:45										2	19	45	67:12
limit	line	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
24	110	0:45										5	19	60	85:12
24	120	0:45										8	21	72	102:12
24	130	0:45										11	25	82	119:12
24	140	0:45										13	30	96	140:12
24	150	0:45										14	40	109	164:12
24	160	0:45										16	52	127	196:12
24	170	0:45										19	61	145	226:12
24	180	0:45										24	68	163	256:12
24	190	0:45										29	75	178	283:12
24	200	0:36									1	32	82	194	310:12
24	210	0:36									1	36	88	213	339:12
24	220	0:36									2	40	95	232	370:12
24	230	0:36									2	50	99	250	402:12
24	240	0:36									5	56	105	267	434:12
24	250	0:36									8	61	117	278	465:12
24	260	0:36									10	66	132	286	495:12
24	270	0:36									13	71	146	292	523:12
24	280	0:36									15	76	159	300	551:12
24	290	0:36									17	80	172	306	576:12
24	300	0:36									19	84	184	314	602:12
24	310	0:36									20	89	196	319	625:12

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
24	320	0:36									22	93	208	325	649:12
27	30	1:21												0	1:21
27	40	1:12												10	11:21
27	50	1:03											4	17	22:21
27	60	1:03											12	18	31:21
27	70	0:54										1	18	20	40:21
limit line															
27	80	0:54										7	19	37	64:21
27	90	0:54										13	18	56	88:21
27	100	0:54										17	19	73	110:21
27	110	0:45									3	18	25	85	132:21
27	120	0:45									6	18	34	101	160:21
27	130	0:45									9	18	50	119	197:21
27	140	0:45									11	20	63	141	236:21
27	150	0:45									13	25	72	163	274:21
27	160	0:45									14	31	81	182	309:21
27	170	0:45									16	35	89	202	343:21
27	180	0:45									17	44	93	227	382:21
27	190	0:45									21	53	101	249	425:21
30	24	1:30												0	1:30
30	25	1:21												1	2:30
30	30	1:21												7	8:30
30	35	1:12											1	11	13:30
30	40	1:12											6	13	20:30
30	45	1:12											9	17	27:30

TBL-P1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM: ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
30	50	1:03										2	11	19	33:30
30	55	1:03										4	15	18	38:30
30	60	1:03										6	18	18	43:30
30	65	1:03										10	18	27	56:30
30	70	1:03										14	18	39	72:30
limit line															
30	75	1:03										18	18	49	86:30
30	80	0:54									2	19	19	60	101:30
30	90	0:54									9	18	21	80	129:30
30	100	0:54									14	19	28	98	160:30
30	110	0:54									18	19	48	115	201:30
33	20	1:39												0	1:39
33	25	1:30												7	8:39
33	30	1:21											3	11	15:39
33	35	1:21											9	12	22:39
33	40	1:12										3	11	15	30:39
33	45	1:12										7	11	18	37:39
limit line															
33	50	1:12										10	14	19	44:39
33	55	1:03									2	11	17	22	53:39
33	60	1:03									5	12	19	35	72:39
33	65	1:03									7	15	19	48	90:39
33	70	1:03									9	18	18	61	107:39
33	80	1:03									16	19	21	83	140:39
33	90	0:54								5	18	19	36	101	180:39
36	18	1:48												0	1:48

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	DECOMPRESSION STOPS (MSW) STOP TIMES (MIN) 36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
36	20	1:39												4	5:48
36	25	1:30											2	11	14:48
36	30	1:30											10	11	22:48
36	35	1:21										5	11	13	30:48
36	40	1:21										11	10	17	39:48
limit line															
36	45	1:12									5	10	12	19	47:48
36	50	1:12									8	11	16	26	62:48
36	55	1:03								1	11	11	18	42	84:48
36	60	1:03								3	11	15	19	55	104:48
36	70	1:03								8	13	19	21	82	144:48
36	80	1:03								12	18	19	38	102	190:48
39	16	1:57												0	1:57
39	20	1:48												9	10:57
39	25	1:39											8	11	20:57
39	30	1:30										6	11	10	28:57
39	35	1:21									2	11	11	14	39:57
39	40	1:21									8	11	10	18	48:57
limit line															
39	45	1:12								2	11	11	13	29	67:57
39	50	1:12								6	11	11	17	46	92:57
39	60	1:03							2	11	11	17	19	78	139:57
39	70	1:03							7	10	17	19	36	101	191:57
42	13	2:06												0	2:06
42	15	1:57												2	4:06
42	20	1:48											4	10	16:06

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
limit line															
46	35	1:33								9	10	11	11	25	68:18
46	40	1:24							5	11	10	11	15	50	104:18
46	45	1:24							11	11	10	11	19	72	136:18
46	50	1:15						5	11	11	10	16	27	87	169:18
46	60	1:06					2	11	11	11	16	19	61	132	265:18
46	70	1:06					8	11	10	17	19	31	88	184	370:18
limit line															
48	9	2:24												0	2:24
48	10	2:15												1	3:24
48	15	1:57										1	3	6	12:24
48	20	1:48									1	3	10	11	27:24
48	25	1:48									5	11	10	11	39:24
48	30	1:39								5	10	11	11	15	54:24
48	40	1:30							10	11	11	10	16	62	122:24
48	50	1:21						11	11	10	11	18	35	100	198:24
limit line															
51	8	2:33												0	2:33
51	10	2:24												3	5:33
51	15	2:06										3	4	7	16:33
51	20	1:48								1	3	4	11	11	32:33
51	25	1:48								2	9	11	10	11	45:33
51	30	1:48								11	11	11	11	22	68:33
51	40	1:30						7	11	11	10	11	23	77	152:33
51	50	1:21					9	11	10	11	13	19	59	127	261:33

TBLP1 VVAL59 (METERS)

.70 ATA FIXED PO2 IN NITROGEN RATES: DESCENT 20 MPM; ASCENT 20 MPM

DEPTH (MSW)	BTM TIM (M)	TM TO FIRST STOP (M:S)	36	33	30	27	24	21	18	15	12	9	6	3	TOTAL ASCENT TIME (M:S)
			DECOMPRESSION STOPS (MSW) STOP TIMES (MIN)												
42	25	1:39										4	10	11	27:06
42	30	1:30									2	11	10	12	37:06
42	35	1:30									9	11	11	15	48:06
limit line															
42	40	1:21								5	11	11	11	27	67:06
42	45	1:21								10	11	11	16	46	96:06
42	50	1:12							4	11	11	12	19	65	124:06
42	60	1:12							11	11	12	19	28	96	179:06
42	70	1:03						6	10	13	18	19	62	135	265:06
45	11	2:15												0	2:15
45	15	1:57											1	5	8:15
45	20	1:48										1	8	11	22:15
45	25	1:48										10	10	11	33:15
45	30	1:39									9	10	11	13	45:15
limit line															
45	35	1:30								6	11	11	10	22	62:15
45	40	1:21							2	11	11	10	14	44	94:15
45	45	1:21							8	11	11	10	19	65	126:15
45	50	1:12						2	11	11	11	14	24	82	157:15
45	60	1:12						10	11	10	16	18	54	119	240:15
45	70	1:03					5	10	11	16	19	27	82	172	344:15
46	10	2:18												0	2:18
46	15	2:00											2	5	9:18
46	20	1:51										2	9	10	23:18
46	25	1:42									1	11	10	11	35:18
46	30	1:42									11	11	10	13	47:18

APPENDIX H

CONSTANT 0.7 ATA PO_2 PHASE I & II

DIVE PROFILE COMPARISONS

All times shown in minutes.

Times indicate total time at indicated depth only. All ascents and descents at 60 FPM.

Total times include time at depth plus all stop times plus time required for ascents and descents.

Profile descriptions for Profiles 3-12 in Table 2 of Reference (8).

Profile descriptions for Profiles 20-30 in Table 9 of Reference (1).

Profiles 1-12 were used for Phase I testing of the Constant 0.7 ATA PO_2 in N_2 Decompression Tables [Reference (8)]. Profiles 20-30 were used in Phase II testing [Reference (1)]. All profiles for VVAL18, VVAL29, and VVAL59 are shown. Other profiles shown were only those actually tested. Test results are shown in the last row as:

Total Man Dives/Number Cases of Decompression Sickness.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 1 (175/30)*2 ; 10/60

Stops (FSW)	# MVAL1	# MVAL2	# MVAL3	VVAL29	VVAL59
175	30.00	30.00	30.00	30.00	30.00
70	---	---	---	0.87	---
60	---	0.09	1.38	2.82	10.28
50	1.45	2.52	3.26	3.30	10.90
40	5.09	6.02	6.51	6.38	10.90
30	7.70	6.91	10.06	11.04	10.90
20	16.90	16.37	17.51	14.87	19.08
10	60.00	60.00	60.00	60.00	60.00
175	30.00	30.00	30.00	30.00	30.00
70	---	---	---	0.69	3.18
60	---	0.01	1.30	2.82	10.90
50	1.37	2.52	3.20	2.82	10.90
40	5.12	6.05	6.51	8.68	10.90
30	13.82	12.32	15.51	19.95	19.96
20	23.13	28.95	30.76	80.44	96.09
10	48.31	52.42	57.03	215.06	202.43
TOTAL	254.22	265.51	284.37	501.07	547.76
RESULTS (Dives/DCS)	8/2	19/1	25/0		

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 2 175/60

Stops (FSW)	# MVAL1	# MVAL2	VVAL29	VVAL59
175	60.00	60.00	60.00	60.00
100	---	---	---	3.63
90	---	---	3.11	10.90
80	---	---	6.38	10.90
70	1.09	3.23	8.80	10.90
60	6.51	5.37	14.87	17.10
50	13.42	12.88	14.87	21.45
40	14.40	14.40	19.52	21.45
30	18.35	24.61	52.29	65.46
20	36.15	36.92	85.09	100.04
10	55.14	59.26	263.10	257.57
TOTAL	210.88	222.50	533.85	585.23
RESULTS (Dives/DCS)	10/3	9/2		

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 3 (150/30)*2 ; 30/120

Stops (FSW)	# MVAL2	# MVAL3	# MVAL5	VVAL18	VVAL29	VVAL59
150		30.00	30.00	30.00	30.00	30.00
90	---	---	0.58	---	---	---
80	---	---	1.52	---	---	---
70	---	---	2.94	---	---	---
60	---	---	3.56	---	---	---
50	---	0.65	3.77	2.33	0.19	2.54
40	2.23	3.22	7.69	6.94	2.82	10.90
30	120.00	120.00	120.00	120.00	120.00	120.00
150	30.00	30.00	30.00	30.00	30.00	30.00
90	---	---	0.60	---	---	---
80	---	---	1.52	---	---	---
70	---	---	3.24	---	---	---
60	---	---	3.56	---	---	---
50	---	0.89	5.08	3.37	0.60	9.56
40	3.70	5.02	8.16	14.89	4.89	10.90
30	9.27	12.78	11.85	28.26	14.87	16.38
20	24.83	26.93	20.38	31.04	56.19	55.07
10	50.25	54.72	44.88	72.84	115.91	137.85
TOTAL	279.28	293.20	308.32	348.67	384.47	432.20
RESULTS (Dives/DCS)	8/0	39/1	28/0			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 4 (125/30)*3 ; (10/30)*20

Stops (FSW)	# MVAL2	# MVAL3	# MVAL5	VVAL18	VVAL29	VVAL59
125	30.00	30.00	30.00	30.00	30.00	30.00
70	---	---	0.76	---	---	---
60	---	---	1.86	---	---	---
50	---	---	3.77	---	---	---
40	---	---	4.00	---	---	---
30	1.78	3.09	7.44	0.71	---	5.87
20	7.05	7.81	9.24	10.85	5.52	10.90
10	30.00	30.00	30.00	30.00	30.00	30.00
125	30.00	30.00	30.00	30.00	30.00	30.00
70	---	---	0.75	---	---	---
60	---	---	1.80	---	---	---
50	---	---	3.77	---	---	---
40	---	---	4.00	4.47	---	5.66
30	3.37	5.52	8.67	28.26	8.71	12.44
20	14.84	17.51	15.48	28.26	14.87	21.45
10	---	---	30.00	30.00	30.00	30.00
125	---	---	30.00	30.00	30.00	30.00
70	---	---	0.75	---	---	---
60	---	---	1.78	---	---	---
50	---	---	3.77	---	---	---
40	---	---	4.00	4.47	---	3.05
30	2.80	6.12	8.39	28.26	8.71	18.33
20	24.15	25.43	16.34	28.26	66.23	56.64
10	49.71	53.69	41.27	60.84	164.39	156.76
TOTAL	265.53	280.99	299.69	356.23	430.27	452.93
RESULTS (Dives/DCS)	10/0	37/2	40/0			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 5 (75/30)*5 ; (10/15)*4

Stops (FSW)	# MVAL2	# MVAL3	# MVAL5	VVAL18	VVAL29	VVAL59
75	30.00	30.00	30.00	30.00	30.00	30.00
30	---	---	1.29	---	---	---
20	---	---	4.17	---	---	---
10	15.00	15.00	15.00	15.00	15.00	15.00
75	30.00	30.00	30.00	30.00	30.00	30.00
30	---	---	1.29	---	---	---
20	---	---	4.87	---	---	---
10	15.00	15.00	15.00	15.00	15.00	15.00
75	30.00	30.00	30.00	30.00	30.00	30.00
30	---	---	1.29	---	---	---
20	---	---	5.39	---	---	---
10	15.00	15.00	15.00	15.00	15.00	15.00
75	30.00	30.00	30.00	30.00	30.00	30.00
30	---	---	1.29	---	---	---
20	---	0.58	5.39	10.40	---	5.77
10	15.00	15.00	15.00	15.00	15.00	15.00
75	30.00	30.00	30.00	30.00	30.00	30.00
30	---	---	1.29	---	---	---
20	---	1.66	5.39	10.91	4.33	6.37
10	36.30	43.00	24.58	57.65	84.32	90.32
TOTAL	257.47	266.40	277.40	300.12	309.82	326.63
RESULTS (Dives/DCS)	7/0	18/0	30/0			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 6 (150/60)

Stops (FSW)	# MVAL2	# MVAL3	# MVAL 4	# MVAL5	VVAL18	# VVAL29	VVAL59
150	60.00	60.00	60.00	60.00	60.00	60.00	60.00
100	----	----	----	0.03	----	----	----
90	----	----	----	1.59	----	----	----
80	----	----	----	3.19	----	----	1.28
70	----	----	----	5.71	5.31	1.73	10.90
60	0.86	3.12	4.48	7.26	14.05	6.67	10.90
50	5.80	7.65	9.80	7.69	26.20	14.87	13.86
40	12.58	15.09	16.22	14.74	28.26	14.87	21.45
30	15.55	16.21	17.50	17.50	28.26	18.10	21.45
20	30.91	33.60	40.38	26.77	33.92	62.30	67.55
10	43.32	53.34	63.07	42.80	78.31	112.81	141.49
TOTAL	179.02	194.01	216.46	192.28	279.31	296.35	353.88
RESULTS (Dives/DCS)	9/0	38/4	10/1	20/3		9/2	

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 7 150/45

Stops (FSW)	# MVAL5	VVAL18	VVAL29	VVAL59
150	45.00	45.00	45.00	45.00
100	0.01	---	---	---
90	0.76	---	---	---
80	3.17	---	---	---
70	3.36	---	---	0.40
60	5.48	4.12	---	10.90
50	7.69	14.05	6.38	10.90
40	8.16	17.30	10.43	10.90
30	15.26	28.26	14.87	18.47
20	18.63	28.26	18.46	21.45
10	33.87	38.11	73.33	81.32
TOTAL	146.38	180.10	174.68	204.34
RESULTS (Dives/DCS)	10/3			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 8 100/60

Stops (FSW)	# MVAL5	VVAL18	# VVAL29	VVAL59
100	60.00	60.00	60.00	60.00
50	2.38	---	---	---
40	5.78	---	---	---
30	8.68	8.67	3.86	8.35
20	14.21	28.26	14.87	21.45
10	19.85	28.26	30.93	22.13
TOTAL	114.23	128.52	113.00	115.26
RESULTS (Dives/DCS)	10/1		27/0	

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 9 150/30

Stops (FSW)	# MVAL5	VVAL18	# VVAL29	VVAL59
150	30.00	30.00	30.00	30.00
90	0.58	---	---	---
80	1.52	---	---	---
70	2.94	---	---	---
60	3.56	---	---	---
50	3.77	2.33	0.19	2.54
40	7.69	6.94	2.82	10.90
30	8.68	11.58	5.83	10.90
20	14.01	21.62	13.02	11.20
10	19.85	28.26	16.50	21.45
TOTAL	97.59	105.73	73.36	91.99
RESULTS (Dives/DCS)	20/0		19/0	

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 10   100/45

Stops (FSW)	# MVAL5	VVAL18	VVAL29	VVAL59
100	45.00	45.00	45.00	45.00
50	1.[illegible]	---	---	---
40	4.00	---	---	---
30	7.18	---	---	---
20	9.24	12.59	5.99	11.41
10	17.97	28.26	14.87	21.45
TOTAL	88.44	89.18	69.19	81.20
RESULTS (Dives/DCS)	20/0			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 11 (150/30)*2 ; 10/90

Stops (FSW)	# MVAL5	VVAL18	VVAL29	VVAL59
150	30.00	30.00	30.00	30.00
90	0.58	---	---	---
80	1.52	---	---	---
70	2.94	---	---	---
60	3.56	---	---	---
50	3.77	2.33	0.19	2.54
40	7.69	6.94	2.82	10.90
30	8.68	11.58	5.83	10.90
20	14.01	21.62	13.02	11.20
10	90.00	90.00	90.00	90.00
150	30.00	30.00	30.00	30.00
90	0.58	---	---	---
80	1.52	---	---	---
70	2.82	---	---	---
60	3.56	---	---	---
50	3.77	1.91	---	4.29
40	7.22	6.94	2.82	10.90
30	8.68	21.45	4.84	10.90
20	15.56	28.26	22.66	17.35
10	30.69	37.21	92.08	112.86
TOTAL	276.80	297.91	303.94	351.51
RESULTS (Dives/DCS)	10/1			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 12 75/120

Stops (FSW)	# MVAL5	VVAL18	VVAL29	VVAL59
75	120.00	120.00	120.00	120.00
30	6.23	---	---	1.46
20	16.79	28.12	15.33	21.45
10	28.25	52.12	67.60	66.04
TOTAL	173.75	202.74	205.43	211.45
RESULTS (Dives/DCS)	20/0			

Profiles actually tested.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 20 (60/ND)*3;(0/80)*2

Stops (FSW)	# MVAL83	# MVAL92	# MVAL97	# VVAL14	VVAL18	VVAL29	VVAL59
60	71.06	66.64	66.64	83.58	73.20	75.60	69.52
0	80.00	80.00	80.00	80.00	80.00	80.00	80.00
60	43.41	44.95	41.30	22.45 (31.84)	23.18 (34.75)	51.93	50.41
0	80.00	80.00	80.00	80.00	80.00	80.00	80.00
60	42.63	34.85	40.22	16.05 (25.95)	23.18 (30.27)	26.84	27.73
TOTAL	323.10	309.44	314.16	288.08 (307.37)	285.55 (304.22)	320.37	313.66
RESULTS (Dives/ DCS)	10/1	9/0	10/0	10/1			

Profile actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and were used in tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 21 40/ND ; 0/80 ; 100/ND

Stops (FSW)	# MVAL97	# VVAL14	VVAL18	VVAL29	VVAL59
40	210.24	366.54	366.54	323.22	363.33
0	80.00	80.00	80.00	80.00	80.00
100	15.78	4.38 (7.99)	4.38 (7.99)	9.53	7.14
TOTAL	310.69	455.59 (459.19)	455.59 (459.19)	417.42	455.14
RESULTS (Dives/DCS)	20/0	10/0			

Profiles actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and <u>were</u> used in tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 22 (100/ND)*4 ; (0/80)*3

Stops (FSW)	# MVAL92	# MVAL97	# VVAL09	# VVAL14	VVAL18	VVAL29	VVAL59
100	18.23	18.23	19.84	28.47	26.18	26.59	22.34
0	80.00	80.00	80.00	80.00	80.00	80.00	80.00
100	18.20	18.20	10.59 (14.56)	5.78 (9.79)	5.48 (9.36)	19.75	17.54
0	80.00	80.00	80.00	80.00	80.00	80.00	80.00
100	18.20	16.98	5.86 (9.36)	5.78 (9.79)	5.48 (9.36)	15.66	16.04
0	80.00	80.00	80.00	80.00	80.00	80.00	80.00
100	13.63	15.78	5.48 (9.36)	5.78 (9.79)	5.48 (9.36)	9.53	10.65
TOTAL	321.59	322.52	295.11 (306.45)	299.14 (311.17)	295.96 (307.59)	324.87	319.90
RESULTS (Dives/ DCS)	10/0	10/1	9/0	10/0			

Profile actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and were used in tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 23 (80/ND)*4 ; (0/80)*2 ; (0/60)*1

Stops (FSW)	# MVAL97	# VVAL09	VVAL18	VVAL29	VVAL59
80	35.66	38.65	38.65	39.39	37.06
0	80.00	80.00	80.00	80.00	80.00
80	25.85	9.46 (15.27)	9.46 (15.27)	30.19	24.73
0	80.00	80.00	80.00	80.00	80.00
80	23.08	9.46 (14.45)	9.46 (15.27)	19.86	24.47
0	60.00	60.00	60.00	60.00	60.00
80	19.01	6.25 (9.15)	7.29 (11.87)	10.93	8.36
TOTAL	334.27	294.48 (308.19)	295.52 (311.73)	331.02	325.29
RESULTS (Dives/DCS)	18/2	19/0			

Profiles actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and <u>were</u> used in tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 24 (150/27, 24) ; (0/80)*2 ; 100/ND

Stops (FSW)	# MVAL97	MVAL18	VVAL29	VVAL59
150	*27.00*	*27.00*	*27.00*	*27.00*
90	0.48	---	---	---
80	1.52	---	---	---
70	2.26	---	---	---
60	3.56	---	---	---
50	3.77	---	---	---
40	6.15	6.83	2.02	8.16
30	8.68	7.20	3.73	10.90
20	11.22	16.93	10.02	10.90
10	28.24	28.26	14.87	18.08
0	80.00	80.00	80.00	80.00
150	24.00	24.00	24.00	24.00
90	0.31	---	---	---
80	1.52	---	---	---
70	1.60	---	---	---
60	3.37	---	---	---
50	3.77	---	---	---
40	4.38	8.80 (4.24)	0.81	6.04
30	8.68	26.69 (24.00)	2.82	10.90
20	10.96	28.26 (28.26)	15.17	15.91
10	40.44	32.85 (30.27)	77.36	82.48
0	60.00	60.00	60.00	60.00
100	12.83	3.37 (6.18)	7.01	5.19
TOTAL	358.05	363.51 (356.51)	338.13	372.90
RESULTS (Dives/DCS)	18/5			

Profiles actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1).

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 24A (150/30)*2 ; 0/80

Stops (FSW)	# VVAL18	VVAL29	VVAL59
150	30.00	30.00	30.00
50	2.33	0.19	2.54
40	6.94	2.82	6.94
30	11.58	5.83	11.58
20	21.62	13.02	21.62
10	28.26	16.50	28.26
0	80.00	80.00	80.00
150	30.00	30.00	30.00
40	21.87 (17.83)	2.82	10.90
30	28.26 (28.26)	11.14	11.79
20	28.26 (28.26)	37.40	38.53
10	52.63 (47.10)	92.34	113.67
TOTAL	356.37 (344.31)	332.24	387.17
RESULTS (Dives/DCS)	10/1		

Profiles actually tested

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) but were not used in tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 25A (100/60, 50) ; 0/80

Stops (FSW)	# VVAL18	VVAL29	VVAL59
100	60.00	60.00	60.00
30	8.67	3.86	8.35
20	28.26	14.87	21.45
10	28.26	30.93	22.13
0	80.00	80.00	80.00
100	50.00	50.00	50.00
30	22.57 (17.83)	---	7.16
20	28.26 (28.26)	28.01	31.69
10	56.41 (52.72)	100.35	112.86
TOTAL	369.10 (360.67)	374.70	400.29
RESULTS (Dives/DCS)	10/0		

Profiles actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) but were <u>not</u> used for tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 26 (80/90, 85) ; 0/60

	Stops (FSW)	VVAL18	VVAL29	VVAL59
	80	90.00	90.00	90.00
	20	25.32	12.55	20.86
	10	35.68	42.45	35.67
	0	60.00	60.00	60.00
	80	85.00	85.00	85.00
	20	46.10 (45.93)	44.33	2.07
	10	68.56 (67.39)	159.27	51.25
TOTAL		425.15 (419.84)	498.93	150.63

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1).

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 27 (120/ND)*4 ; (0/80)*2 ; (0/60)*1

Stops (FSW)	# VVAL18	VVAL29	VVAL59
120	17.45	18.87	15.78
0	80.00	80.00	80.00
120	5.26 (8.08)	14.82	12.73
0	80.00	80.00	80.00
120	3.45 (6.35)	12.48	11.75
0	60.00	60.00	60.00
120	2.40 (4.63)	4.77	7.45
TOTAL	264.56 (272.51)	286.95	283.71
RESULTS (Dives/DCS)	10/0		

Profiles actually tested.

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and were used for tested profiles.

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 28 (140/ND)*3 ; (0/80)*2 ; (0/60)

	Stops (FSW)	VVAL18	VVAL29	VVAL59
	140	10.67	12.85	10.61
	0	80.00	80.00	80.00
	140	5.96 (8.39)	12.25	9.63
	0	80.00	80.00	80.00
	140	2.36 (4.44)	10.30	9.31
	0	60.00	60.00	60.00
	140	1.30 (3.07)	3.26	6.46
TOTAL		258.96 (265.24)	277.33	274.68

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1).

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 29 (150/ND)*4 ; (0/80)*2 ; (0/60)*1

	Stops (FSW)	VVAL18	VVAL29	VVAL59
	150	8.54	10.46	8.50
	0	80.00	80.00	80.00
	150	5.19 (7.39)	10.46	8.41
	0	80.00	80.00	80.00
	150	2.49 (4.34)	10.08	8.18
	0	60.00	60.00	60.00
	150	0.85 (2.46)	2.80	5.76
TOTAL		257.08 (262.74)	273.81	270.83

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1).

PHASE I & II DIVE PROFILE COMPARISON

PROFILE 30 50/ND; 0.80; 80/ND

Stops (FSW)	# VVAL18	VVAL29	VVAL59
50	142.22	146.91	140.43
0	80.00	80.00	80.00
80	7.77 (13.15)	16.88	18.35
TOTAL	234.32 (239.70)	248.13	243.12
RESULTS (Dives/DCS)	10/0		

Profiles actually tested

Times in parenthesis assume 30% O_2 at 1 ATA (See Note 1) and were used for tested profiles.

Note 1. During Phase II testing of the constant 0.7 ATA PO_2 in N_2 Decompression Model, certain surface intervals were assumed to occur with the diver breathing a 30% O_2 mix. The times shown in parenthesis are those resulting from breathing this high PO_2. Profiles 20, 21, 22, 23, 27, and 30 were tested assuming that this higher PO_2 was breathed during surface intervals. Note that this increase in PO_2 was an adjustment to the computer program only, the divers actually breathed air during the surface interval but dove on the schedules indicated by the times in parenthesis. See reference (1) for details.

END

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