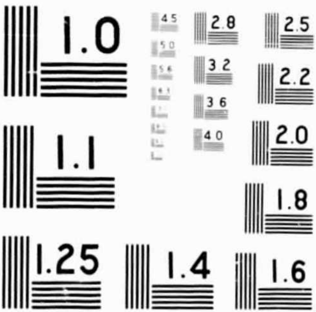


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS – 1963

DECOMPRESSION PROCEDURES FOR THE SAFE ASCENT OF AEROSPACE PERSONNEL FROM GROUND LEVEL TO ALTITUDE

Contract NAS 9-6978

Supplement A

To Final Report

To:

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

Submitted By

Union Carbide Corporation
Linde Division
Technical Center
Tarrytown, New York
10591

28 February 1970

NASA CR 108420

TABLE OF CONTENTS

APPENDIX

I. INTRODUCTION AND SUMMARY

Under the terms of Contract NAS 9-6978 we have subjected 388 manned altitude flight records (including 73 flights in which a mixture of helium and oxygen was breathed) to a theoretical analysis to determine those parameters which are important in the construction of decompression tables for aerospace personnel. The results of this analysis have been reported to the National Aeronautics and Space Administration on 4 May 1968 in the form of a Final Report on Contract NAS 9-6978 entitled "Decompression Procedures for the Safe Ascent of Aerospace Personnel From Ground Level to Altitude." Subsequent to the preparation of that report we have been able to collect and analyse an additional 1238 manned altitude flight records under an extension of Contract NAS 9-6978. The present document, issued as Supplement A to our Final Report on Contract NAS 9-6978 (to be referred to as "Final Report" throughout this narrative) describes the results of our analyses of the total body of 1553 flight records available to us in which nitrogen was the only inert gas breathed.

Under otherwise identical circumstances the duration of exposure to a given altitude determines the degree of risk of decompression sickness that is incurred. Recognizing this, we developed from the results of our analyses the maximum tissue nitrogen tensions in the slowest hypothetical gas exchange compartment of the Tonawanda II model of decompression (c. f. Final Report, page 2) that permit safe ascent and exposure to a given target altitude for up to 10, 60, and 120 minutes, respectively. This information, in turn, was used to compute, as a function of the duration of the intended exposure to altitude, the preoxygenation time at ground level required for safe ascent to several target altitudes as outlined in the Statement of Work section of this report.

II. DESCRIPTION OF EFFORT

Under the terms of Contract NAS 9-6978 we set out to analyze altitude decompression histories accumulated under controlled laboratory conditions, compute inert-gas tensions in various hypothetical half-time tissues throughout these flights, and to correlate the value and time course of change of these tensions with the incidence of decompression sickness.

We applied to the Commander, U. S. Air Force School of Aerospace Medicine, for permission to select 1000 (one thousand) nitrogen-oxygen altitude decompression histories accumulated in controlled chamber experiments.

These histories were selected, as far as possible, in such a way as to complement in terms of altitude attained, and incidence of decompression sickness sustained, the 388 histories already analyzed by us earlier.

These histories were subjected to computer evaluation consisting of the calculation of nitrogen partial pressures as a function of total pressure, time spent at that pressure and specific time constants of tissue gas exchange in 15 hypothetical gas exchange compartments.

Computed tissue tensions, flight profile characteristics, and information pertaining to the individual subject, such as his activities and responses during the flight, were recorded and stored on tape and subsequently analyzed by appropriate computer operations.

From this information, plus information already obtained under Contract NAS 9-6978, we then prepared a set of nitrogen partial pressures for the ascent-limiting hypothetical gas exchange compartment which, if not exceeded during ascent, will permit the most rapid decompression consistent with acceptable decompression risk.

Based on these ascent-limiting nitrogen partial pressures we constructed decompression tables for ascent to total pressures ranging in 10 mm HG intervals from 500 to 150 mm HG after saturation with nitrogen at partial pressures ranging in 10 mm HG intervals from 600 to 50 mm Hg. This information was displayed as pre-oxygenation time required to ascend to the target total pressure within 60 seconds.

III. RESULTS AND DISCUSSION

A. Analysis of 1553 Flight Records.

Under an extension of contract NAS 9-6978 we were able to secure a total of 1245 additional manned altitude flight records in which nitrogen was the only inert gas breathed. These records were obtained principally from the U. S. Air Force School of Aerospace Medicine at San Antonio* in two sets (1006 and 232 records, respectively); seven dive/fly decompression records generated by the Experimental Diving Unit of the U. S. Navy were secured through the courtesy of Dr. Maxwell W. Goodman.

Of this total, seven (4 USAF and 3 USN) records were found to be sufficiently deficient or inconsistent in information content to merit their elimination. The remaining 1238 records were processed as described in our Final Report (p. 11), and the results transcribed onto magnetic tape. This processed information was merged with that obtained from the group of 315 nitrogen-oxygen flight records analyzed previously (c. f. Final Report, p. 19).

The initial two (Analyses No. 12 and 13) of the five computer analyses** performed on the processed flight records followed the approach worked out earlier (c. f. Final Report p. 23). Analysis No. 12 was identical with Analysis No. 10 (c. f. Final Report, Appendix II).

---

* We are indebted to the Commanding Officer of USAF-SAM for granting us access to these records and to Dr. Thomas H. Allen, Maj. Dominic A. Maio and Lt. Col. Sarah E Beard of the School for assisting us generously in acquiring the decompression data on which the work reported herein is based.

** The objectives of these analyses and the procedures followed in their execution are presented in Appendices I and II to this report.

However, when applied to 1006 new altitude flight records, Analysis No. 12 produced results that could not be reconciled with the decompression risk curve derived earlier (c. f. Final Report, Figure 4, p. 29). Characteristic of these new flight records was the observation that in some instances, the incidence of decompression sickness (number of "hits" as a function of $\pi^{15}_{N_2}$) would actually decrease with increasing values of $\pi^{15}_{N_2}$ computed at the moment of arrival of the flight at a pressure-time discontinuity. The following tabulation of results of Analysis No. 12 for 40 flights (out of the group of 1006 new records) which reached the target pressure range of 200-150 mm Hg typefies this characteristic which was not detected by Analysis No. 10.

Target Pressure Range 200-150 mm Hg:

$\pi^{15}_{N_2}$ (mm Hg)	No. of Flights with "Hits" of Grade 2-5	Total Number of Flights	Cumulative Total No. of Flights
376.2-380	1	6	6
398.1-400	3	6	12
413.1-420	8	12	24
423.4	1	2	26
512.3-520	0	13	39
521.9	0	1	40
	13	40	

As can be seen, half of these flights to 200-150 mm Hg resulted in decompression sickness if the value of $\pi^{15}_{N_2}$ on arrival at target pressure fell between 376 and 425 mm Hg. However, 14 "clean" flights to this target pressure were made with initial values of $\pi^{15}_{N_2}$ in excess of 500 mm Hg. The results of Analysis No. 10, however, would predict virtual certainty of decompression sickness in cases where the target pressure range of 200-150 mm Hg is attained with a value of $\pi^{15}_{N_2}$ greater than 500 mm Hg. (c. f. Final Report, Figure 4, p. 29).

Analysis No. 13 was identical with Analysis No. 12 except for the definition of "hit". In Analysis No. 12 a "hit" implied the eventual development of at least slight discomfort or pain (Grade 3) during the flight, in Analysis No. 13 these symptoms had to develop into definite pain, steady and moderate (Grade 4) or into severe pain, severe central nervous system disorders or circulatory collapse (Grade 5) before they were to be considered as "hits". The anomalies seen in the results of Analysis No. 12 were also noted in Analysis No. 13 and raised the probability that we may have overlooked an important environmental parameter in all of our computer analyses to this point. Our intuitive belief was that this parameter was the period of residence at a given altitude.

Considering the dynamics of inert gas transport on ascent to altitude it is obvious that the subject's slowest inert gas exchange compartment (No. 15 in the Tonawanda II Model) will begin to lose nitrogen as soon as ascent from, or oxygen breathing at ground level commences. This decrease in the value of $\pi^{15}_{N_2}$ continues on arrival at target pressure according to equation 11, (Final Report, page 11)

$$\frac{d\pi}{dt} = 0.0085 \frac{\alpha_{water}}{\alpha_{fat}} \left(F_{I_{IG}} [\text{B-37}] - \pi \right). \qquad (11)$$

so that, given sufficient time at target pressure, $\pi^{15}_{N_2}$ will become equal to or less than the prevailing barometric pressure. Thus the status of supersaturation with inert gas at altitude is generally self-limiting, and the risk of decompression sickness will diminish with time at target pressure for the subject who has successfully sustained the initial, and frequently appreciable degree of inert gas supersaturation at target pressure without the occurrence of phase separation in his tissues. On the other hand, a brief exposure to reduced ambient pressure - particularly with nitrogen as the inert gas component of the breathing environment - will, even in the face of initially high values of $\pi^{15}_{N_2}$ frequently fail to provoke the onset of symptoms of decompression sickness. This contention is well supported by the general body of decompression experience, especially that gained in diving applications, and can be explained on the basis of probability (i. e. the chance of a breakdown of the supersaturated state can be expected to depend on the length of the time period during which this metastable system is permitted to exist) and of the relatively slow rate of nitrogen bubble growth. Thus, even if phase separation should have occurred at target pressure, bubble growth growth may not have progressed to the point of subjectively felt symptoms during the brief sojourn at that pressure. In that event, return to the initial pressure level represents unintentional and prophylactic compression therapy.

These considerations make it important to segregate altitude flight experience on the basis of time of exposure to target pressure. Since many of the 1006 new flight records received represented relatively brief stays at altitude, Analysis No. 14 was conducted to eliminate the effect of flight records with a period of residence at target pressure of 0-15 minutes from the results of Analysis No. 12. Analysis No. 15 was done for the purpose of eliminating flight records with a period of residence at target pressure of 0-30 minutes. The results of these analyses performed in each case on 1321 flight records are shown for the target pressure range of 200-150 mm Hg in Table I below.

TABLE I

Results of Analyses No. 12, 14 and 15 of Flights
To the Target Pressure Range of 200-150 mm Hg.

$\pi^{15}N_2$ (m m Hg)	No. of Flights with "Hits" of Grade 2 - 5			Total Number of Flights			Cumulative Total No. of Flights		
	No. 12	No. 14	No. 15	No. 12	No. 14	No. 15	No. 12	No. 14	No. 15
0-100	1	1	0	2	2	0	2	2	0
188-190	0	0	0	14	14	0	16	16	0
190-191	3	3	0	14	14	0	30	30	0
206-210	2	2	0	10	10	0	40	40	0
225-230	10	8	0	24	22	0	64	62	0
233-240	2	1	0	25	24	0	89	86	0
241-255	0	0	0	6	6	0	95	92	0
261-264	2	1	0	21	20	0	116	112	0
270-275	0	0	0	2	2	0	118	114	0
284-290	2	2	0	3	3	0	121	117	0
290-295	16	13	0	29	26	0	150	143	0
309-315	0	0	0	11	11	0	161	154	0
341-348	11	10	0	24	23	0	185	177	0
376-378	1	1	1	6	6	6	191	183	6
398-399	3	3	3	6	6	6	197	189	12
408-419	10	10	7	17	17	11	214	206	23
423-430	14	13	1	42	40	2	256	246	25
430-435	6	6	0	11	11	0	267	257	25
455-467	11	11	0	17	17	0	284	274	25
470-476	15	15	0	17	17	0	301	291	25
512-522	0	0	0	14	8	6	315	299	31
	109	100	12	315	299	31			

This example shows that the relative risk of decompression sickness associated with given range of $\pi^{15}_{N_2}$ is a widely variable entity which in general does not increase monotonously with increasing values of $\pi^{15}_{N_2}$. The absence of any instance of decompression sickness in flights to a target pressure range of 200-150 mm Hg is noted not only for the 14 flights with a range of $\pi^{15}_{N_2}$ values of 512-522 mm Hg but also for the $\pi^{15}_{N_2}$ value ranges of 241-255 (6 flights), 270-275 (2 flights), and 309-315 mm Hg (11 flights). The fact that the decompression risk experienced with the 315 nitrogen-oxygen flights analyzed earlier did increase monotonously (c. f. Final Report, Fig. 4, p. 29) must therefore be considered fortuitous.

It is, however, possible to develop cumulative risk predictions which differ from our earlier approach in that they do not attempt to relate a particular percentage of expected decompression risk to each value of $\pi^{15}_{N_2}$, but rather state this risk in terms of the total body of flight experience gained with initial values of $\pi^{15}_{N_2}$ equal to or less than a particular value. This approach yields fairly consistent results as can be seen from the data displayed in Table II where Analysis No. 10 (315 records) and Analysis No. 12 (1321 records) are shown to produce cumulative percentages of decompression risk that are in reasonably close agreement with one another.

Given the premise that the incidence of decompression sickness is determined in the main by the relationship between the value of $\pi^{15}_{N_2}$ on arrival at target pressure, the magnitude of that target pressure, and the period of residence thereat, it is not appropriate to eliminate flight records from analytical consideration, as was done in Analyses No. 14 and 15, solely on the basis of the time spent at target pressure (TTP). This is due to the observation that within a group of exposures to altitude the occurrence of a "hit" at any given time affects the decompression risk of all flights that exceed that time, and must therefore not be dismissed from consideration. Another weakness of Analyses No. 10 and No. 12-15 is that each flight record, if it involved step-wise ascent was counted as an item at each pressure-time discontinuity until the termination of the flight either by the occurrence of decompression sickness as defined for each Analysis, or by return to ground level. This approach is questionable since a flight record still "clean" at a target pressure of, say, 300 mm Hg which subsequently produces a "hit" on ascent to, say, 180 mm Hg

TABLE II

Cumulative Per Cent Risk of Decompression Sickness
As a Function of Time at Target Pressure (TTP)

A. Target Pressure Range 200-150 mm Hg.

$\pi^{15}_{N_2}$ (mm Hg)	All Values of TTP Analysis No. 10	Analysis No. 12	Analysis No. 13*	TTP> 15 min. Analysis No. 14	TTP > 30 min. Analysis No. 15
≤ 200	13(4/30)	13(4/30)	6(2/31)	13(4/30)	------
≤ 255	19(18/95)	19(18/95)	10(10/97)	16(15/92)	------
≤ 300	25(38/150)	25(38/150)	12(19/153)	22(31/143)	------
≤ 350	26(49/185)	26(49/185)	14(26/188)	23(41/177)	------
≤ 400	26(49/185)	27(53/197)	14(27/200)	24(45/189)	25(4/12)
≤ 450	29(70/241)	31(83/267)	17(47/270)	29(74/257)	48(12/25)
≤ 500	35(96/275)	36(109/301)	21(65/304)	34(100/291)	48(12/25)
≤ 523	---------	35(109/315)	20(65/318)	33(100/299)	39(12/31)

B. Target Pressure Range 250-200 mm Hg.

$\pi^{15}_{N_2}$ (mm Hg)	Analysis No. 10	Analysis No. 12	Analysis No. 13*	Analysis No. 14	Analysis No. 15
≤ 500	------	0(0/15)	0(0/23)	0(0/13)	0(0/3)
≤ 525	------	3(9/257)	0(0/265)	4(9/229)	5(5/100)
≤ 550	------	3(9/273)	0(0/281)	4(9/236)	5(5/101)
≤ 565	------	3(9/288)	0(0/296)	------	------

C. Target Pressure Range 300-250 mm Hg.

$\pi^{15}_{N_2}$ (mm Hg)	Analysis No. 10	Analysis No. 12	Analysis No. 13*	Analysis No. 14	Analysis No. 15
≤ 400	0(0/3)	0(0/5)	0(0/11)	0(0/5)	0(0/2)
≤ 450	9(1/11)	8(1/13)	5(1/20)	8(1/13)	0(0/2)
≤ 500	28(26/91)	31(38/124)	17(24/140)	29(35/121)	41(11/27)
≤ 525	------	8(42/549)	4(25/565)	8(38/482)	5(14/297)

* Decompression Sickness Grades 3-5, all other Analyses based on Grades 2-5.

TABLE II cont'd

C. Target Pressure Range 300-250 mm Hg. (cont'd)

$\leq$ 550	------	7(42/635)	4(25/652)	7(38/511)	5(14/308)
$\leq$ 576	------	7(53/771)	4(28/788)	9(49/542)	7(25/339)

D. Target Pressure Range 350-300 m m Hg.

$\leq$ 464	------	0(0/3)	0(0/16)	0(0/3)	0(0/2)

E. Target Pressure Range 400-350 mm Hg.

$\leq$ 500	0(0/12)	0(0/16)	0(0/27)	0(0/16)	0(0/4)
$\leq$ 600	9(8/88)	9(9/95)	5(6/122)	7(6/90)	------

Figures in parentheses denote the ratio of "hits" to total flight records within each target pressure range.

may have incurred a phase separation already at 300 mm Hg which was exacerbated on further reduction of the ambient pressure. To consider such a flight "clean" at the lower altitude is not sufficiently conservative in practice to suit our purposes.

In Analysis No. 16, involving a total of 1553 flight records, we therefore considered each record only once, i. e. on arrival at the minimum target pressure attained. The computed values of $\pi^{15}_{N_2}$ at that point were grouped in ranges of 20 mm Hg and analyzed in terms of the incidence of decompression sickness occurring as a function of time of exposure to the minimum target pressure attained. A typical result of Analysis No. 16 is shown in Table III.

In the instance described in Table III the data on hand are treated so that the termination of "clean" flights is considered pre-planned, e. g. it is assumed that of 193 flights recorded, only 133 were intended to last between 15 and 25 min. while 1+ 14+ 45= 60 flights were planned to be terminated within the first 15 min. of reaching the target pressure range of 250-200 mm Hg. The two "hits" that occurred up to the 25th minute at target pressure are considered to belong to the remaining 133 "intentional" flights with a time at target pressure of 0-25 min. This is a more conservative method of treating the data at hand than to apportion the 2 "hits" sustained between the 133 "intentional" and the 60 "withdrawn" flights. This conservativism leads to the anomaly that as "clean" flights are being withdrawn from consideration with increasing time at target pressure, the cumulative number of "hits" is ascribed to a monotonously decreasing number of "intentional" flights until, at the last withdrawal, only the recorded "hit" flights are flights remaining under consideration, resulting at this TTP in a technical 100 per cent cumulative incidence of decompression sickness.

TABLE III

Illustrative Example of Analysis No. 16

Target Pressure Range: 250-200 mm Hg

Range of $\pi^{15}_{N_2}$: 500-520 mm Hg

Item	0-5	5-15	15-25	25-35	35-45	45-55	55-65	65-75	75-85	85-95	95-105	105-115	115-125	125-135	135+
1	192	178	133	57	32	18	10	8	7	7	6	6	6	6	6
2	1	0	1	1	0	2	1	0	0	0	0	0	0	0	0
3	1	14	45	76	25	14	8	2	1	0	1	0	0	0	0
4	0.5	0.6	1.5	5.3	9.4	27.8	60.0	75.0	85.7	85.7	100	100	100	100	100
5	0.5	0	0.8	1.8	0	11.1	10	0	0	0	0	0	0	0	0

Where 1 = Total number of flights under consideration within each TTP range.
2 = Number of "hits" experienced in each TTP range.
3 = Number of "programmed dropouts", i.e. flights terminated without incurring decompression sickness.
4 = Cumulative percentage of "hits" in all flights under consideration (Item 2 times 100 divided by the difference between items 1 and 3).
5 = Percentage of "hits" in each TTP range.

B. Development of Ascent-Limiting Values of Tissue Nitrogen Tensions

We developed ascent-limiting (M-) values of tissue nitrogen tensions by selecting, from the results of Analysis No. 16, the maximum values of $\pi^{15}_{N_2}$ permitting ascent to a given target altitude without risk of decompression sickness. This was done for times at target pressure of 10 ± 5, 60 ± 5 and 115+ minutes. The pertinent portions of Analysis No. 16 are presented in Table IV.

Since there were no flight records examined by us that were associated with risk-free ascent to 175 ± 25 mm Hg we arbitrarily assigned an M-value of 150 mm Hg to the target pressure of 150 mm Hg irrespective of the period of exposure to it. By ruling out in this manner the possibility of supersaturation we exercised the most conservative option available to us. For exposure to 225 ± 25 mm Hg for 10 ± 5 min. we chose an M-value of 490 ± 10 mm Hg, for exposure to 275 ± 25 mm Hg the M-values selected were 550 ± 10 mm Hg for 10 ± 5 minutes, 410 ± 10 mm Hg for 60 ± 5 min. and 370 ± 10 mm Hg for 115+min. exposure to target pressure. We selected Workman's M-values for nitrogen as adapted to the 15th compartment of the Tonawanda II Model (cf Final Report, p. 32) of 1152 mm Hg for the target pressure of 760 mm. Using the minimum value of $\pi^{15}_{N_2}$ as M-value where our analysis had produced ranges of that parameter, we could now identify the following ascent-limiting tissue nitrogen tensions:

Target Pressure (mm Hg)	M-value (mm Hg)	For Time at Target Pressure (min.)	Source of M-Values
760	1152	10, 60 and 120	Workman's (1965) Diving Data
275	540	10	Analysis No. 16
225	480		Analysis No. 16
275	400	60	Analysis No. 16
275	360	120	Analysis No. 16
150	150	10, 60 and 120	An arbitrary value

We now attempted to develop three equations expressing M-values as a function of target pressure (TP) for times at TP of 10, 60, and 120+ minutes, respectively.

TABLE IV

Values of Tissue Nitrogen Tensions Limiting
Ascent to Various Target Pressures and Associated
Risks of Decompression Sickness for Three Periods
of Altitude Exposure

Target Pressure (mm Hg) ±25	$\pi^{15}_{N_2}$ (mm Hg) ±10	Cumulative Percent Risk for Times at Target Pressure of: 10± 5 (min.)	60±5 (min.)	115+ (min.)
175	190	7.1	10.7	10.7
225	490	0		
225	510	0.6	60	100
275	370	0	0	0
275	410	0	0	16.7
275	450	0	5	15
275	470	0	5.9	56.3
275	490	0	18.2	100
275	510	0.3		
275	530	0		
275	550	0		
275	570	20.0		

A preliminary graph of the selected individual M-values suggested that the equation M-value = a + b $\log_e$ (TP) might be appropriate. A Linear Regression Program from IBM's Scientific Subroutine Package was used to determine the coefficients a and b which would result in the best fit of the data. The regression results and a plot of the back calculation of the M-values, from the equation, over the range of TP's of interest showed this function to be a poor choice owing to too gentle a curvature over the TP range of 150 mm Hg to 300 mm Hg and too much curvature beyond 300 mm Hg.

The original graph for a time at target pressure (TTP) of 10 minutes indicated a straight line function between TP's of 225 and 760 mm Hg. In addition to this, the selected data for a TTP of 120 minutes, showed only a slight deviation from a straight line. Therefore, we now set up an equation containing the terms of a straight line plus a third term which would be zero for TP equal 150 mm Hg and approach a constant value for TP's greater than 225 mm Hg.

$$\text{M-value} = a + b\,(TP) + c\left[1 - 1/e^{((TP/75)-2)}\right]$$

The results of the regression program and plot of the back-calculated values indicated a much better fit, but the TTP = 10 minute graph still showed too much curvature for TP's greater than 225 mm Hg. The exponent of e was modified to ((TP/5-30) so as to drive the third term more quickly to a constant value. This regression indicated a perfect fit which is not uncommon when so few data points are used. The plot of the back-calculated values showed that the third term became a constant value too soon.

The final equation:

$$\text{M-value} = a + b\,(TP) + c\left[1 - 1/e^{((TP/18.75)-8)}\right]$$

was obtained after three additional attempts. The linear regression program results (labeled MVFT 10, MVFT 60, and MVFT 120) determining the coefficients for a, b, and c, including a table of residuals are presented in Appendix III.

The generated coefficients are tabulated below for convenience:

TTP	a	b	c
10	-37.953	1.2534	237.0604
60	-82.554	1.5504	56.2759
120	-94.945	1.6330	5.885

The M-value equations for times at target pressures of 10, 60 and 120 minutes were then employed to back-calculate M-values for various target pressures. A condensed set of back-calculated M-values is presented in Table V.

Finally, we compared these M-values with Workman's M-values extrapolated linearly to altitude (cf Final Report, p. 32). As can be seen in Table VI and Figure 1, these extrapolated values are uniformly greater than those derived by the present study. This implies that in diving applications the ascent-limiting nitrogen tensions in the slowest inert gas exchange compartment of the human body increase with increasing target pressure at a rate faster than that suggested by Workman.

TABLE V

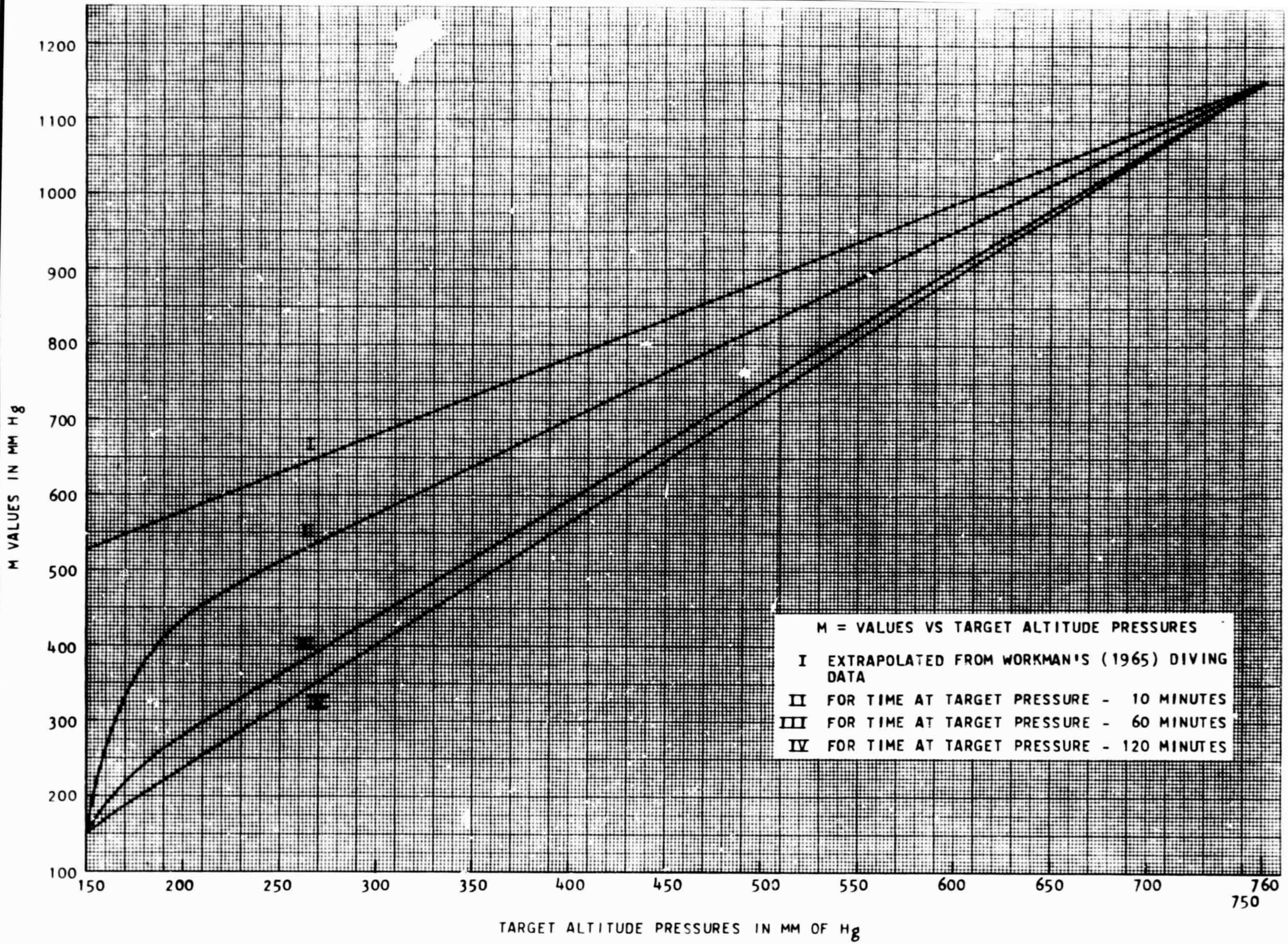
Condensed Set of M-Values
Back-Calculated from the
Final Regression Equations

Target Pressure (mm Hg)	M-Values for Times at Target Pressure of 10 min.	60 min.	120+ min.
150	150	150	150
160	261	189	169
170	331	218	187
180	377	241	204
190	409	262	221
200	433	280	237
210	453	297	254
220	469	313	270
230	484	330	286
240	498	345	303
250	511	361	319
260	524	377	335
270	537	392	352
280	550	408	368
290	562	423	384
300	575	439	401
310	588	454	417
320	600	470	433
330	613	485	450
340	625	501	466
350	638	516	482
400	700	594	564
450	763	671	646
500	826	749	727
550	888	826	809
600	951	904	891
650	1014	981	972
700	1076	1059	1054
750	1139	1136	1136
760	1152	1152	1152

TABLE VI

Suggested Ascent - Limiting Tissue Nitrogen Tensions
for Compartment 15 in mm Hg

Target Pressure (mm Hg)	Extrapolated From Workman's (1965) Data (mm Hg)	Back-calculated M-values for Times at Target Pressure of 10 min.	60 min.	120+ min.
760	1152	1152	1152	1152
710	1100	1089	1074	1070
660	1049	1026	997	989
610	998	964	919	907
560	946	901	842	825
510	895	838	764	744
460	844	776	687	662
410	792	713	609	580
360	741	650	532	499
310	690	588	454	417
260	638	524	377	335
210	587	453	297	254
160	536	261	189	169


M = VALUES VS TARGET ALTITUDE PRESSURES
I EXTRAPOLATED FROM WORKMAN'S (1965) DIVING DATA
II FOR TIME AT TARGET PRESSURE - 10 MINUTES
III FOR TIME AT TARGET PRESSURE - 60 MINUTES
IV FOR TIME AT TARGET PRESSURE - 120 MINUTES
I
M VALUES IN MM Hg
1200
1100
1000
900
800
700
600
500
400
300
200
100
150
200
250
300
350
400
450
500
550
600
650
700
750
760
TARGET ALTITUDE PRESSURES IN MM OF Hg

C. Preoxygenation Times Required for Safe Ascent to Altitude

Utilizing the M-value equations described in the preceding section we integrated the gas transport equation:

$$\frac{d\pi}{dt} = 0.0085 \frac{\alpha \text{ water}}{\alpha \text{ fat}} \left(F_{I_{IG}} [B-37] - \pi \right) \qquad (11)$$

which for nitrogen, and an inspired fraction of nitrogen of 0.02 (oxygen breathing by mask) reduces to

$$\frac{d\pi}{dt} = \frac{0.693}{416} \left(0.02 [B-37] - \pi \right), \qquad (12)$$

and solved it for t by employing as final values of $\pi^{15}_{N_2}$ ascent-limiting (M-) values appropriate for exposures of 10, 60, and 120+ minutes, respectively, to target pressures ranging from 500 to 150 mm Hg and by choosing as initial values of $\pi^{15}_{N_2}$ levels of tissue nitrogen tensions ranging from 50 to 600 mm Hg.

The resulting pre-oxygenation times required for safe ascent to altitude are displayed in Table VII. Although they are nominally describing the "minimum of oxygen breathing at sea level required to attain altitude" safely, it is not necessary that the prescribed period of oxygen breathing take place at sea level.

TABLE VII

Preoxygenation Times Required for Safe Ascent to Altitude

ASCENT TABLES (PREOXYGENATION TIMES)

MIN N2 15 *	825	813	800	788	775	763	750	738	725	713	700	687	675	662	650	637	625	612
ALTITUDE IN	11.1	11.7	12.2	12.7	13.3	13.8	14.4	14.9	15.4	16.1	16.7	17.3	18.0	18.6	19.3	20.0	20.7	21.4
THOUSANDS OF FEET																		
TOTAL PRESSURE	500	490	480	470	460	450	440	430	420	410	400	390	380	370	360	350	340	330
PI N2 15(MM HG)																		
600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
590	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
580	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
570	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
560	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
550	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	[illegible]	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 10 MIN. FLIGHT TIME AT TARGET ALTITUDE.

TABLE VII (Cont'd)

ASCENT TABLES (PREOXYGENATION TIMES)

M N2 15 *	600	587	575	562	549	537	524	511	497	484	469	452	433	409	376	330	260	150
ALTITUDE IN THOUSANDS OF FEET	22.1	22.8	23.6	24.4	25.2	26.0	26.9	27.3	28.7	29.6	30.6	31.5	32.7	33.8	34.9	36.1	37.4	38.7
TOTAL PRESSURE	320	310	300	290	280	270	260	250	240	230	220	210	200	190	180	170	160	150
PI N2 15(MM HG)																		
600	0	14	27	41	55	69	84	99	117	133	153	175	202	238	290	372	522	879
590	0	4	16	30	45	58	74	89	106	123	142	165	192	227	280	361	512	869
580	0	0	6	20	34	48	63	79	96	112	132	155	181	217	269	351	501	858
570	0	0	0	9	24	37	52	68	85	101	121	144	170	206	258	340	491	847
560	0	0	0	0	13	26	41	57	74	91	110	133	160	195	247	329	480	836
550	0	0	0	0	2	15	30	46	63	79	99	122	148	184	236	318	469	825
540	0	0	0	0	0	4	19	35	52	68	88	111	137	173	225	307	457	814
530	0	0	0	0	0	0	8	23	40	57	76	99	126	161	214	295	446	802
520	0	0	0	0	0	0	0	11	28	45	64	87	114	149	202	283	434	791
510	0	0	0	0	0	0	0	0	16	33	52	75	102	137	190	271	422	779
500	0	0	0	0	0	0	0	0	4	21	40	63	90	125	178	259	410	766
490	0	0	0	0	0	0	0	0	0	8	28	50	77	113	165	247	397	754
480	0	0	0	0	0	0	0	0	0	0	15	38	64	100	152	234	385	741
470	0	0	0	0	0	0	0	0	0	0	2	25	51	87	139	221	371	728
460	0	0	0	0	0	0	0	0	0	0	0	11	38	73	126	208	358	715
450	0	0	0	0	0	0	0	0	0	0	0	0	24	60	112	194	345	701
440	0	0	0	0	0	0	0	0	0	0	0	0	10	46	98	180	331	687
430	0	0	0	0	0	0	0	0	0	0	0	0	0	32	84	166	316	673
420	0	0	0	0	0	0	0	0	0	0	0	0	0	17	69	151	302	658
410	0	0	0	0	0	0	0	0	0	0	0	0	0	2	54	136	287	643
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	121	271	628
390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	105	256	612
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	89	239	596
370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	223	579
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	206	562
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	188	545
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	170	526
330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	151	508
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	488
310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	468
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	448
290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	426
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	404
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	381
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	357
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	332
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	306
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	279
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	221
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	189
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 10 MIN. FLIGHT TIME AT TARGET ALTITUDE.

TABLE VII (Cont'd)

ASCENT TABLES (PREOXYGENATION TIMES)

M N2 15 *	748	733	717	702	686	671	655	640	624	609	593	578	562	547	531	516	500	485
ALTITUDE IN THOUSANDS OF FEET	11.1	11.7	12.2	12.7	13.3	13.8	14.4	14.9	15.4	16.1	16.7	17.3	18.0	18.6	19.3	20.0	20.7	21.4
TOTAL PRESSURE	500	490	480	470	460	450	440	430	420	410	400	390	380	370	360	350	340	330
PI N2 15(MM HG)																		
600	0	0	0	0	0	0	0	0	0	0	8	23	41	57	76	93	113	132
590	0	0	0	0	0	0	0	0	0	0	0	13	30	47	65	83	103	121
580	0	0	0	0	0	0	0	0	0	0	0	3	20	37	55	73	92	111
570	0	0	0	0	0	0	0	0	0	0	0	0	9	26	44	62	81	100
560	0	0	0	0	0	0	0	0	0	0	0	0	0	15	33	51	70	89
550	0	0	0	0	0	0	0	0	0	0	0	0	0	4	22	40	59	78
540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	29	48	67
530	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	36	55
520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25	44
510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	32
500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 60 MIN. FLIGHT TIME AT TARGET ALTITUDE.

TABLE VII (Cont'd)

ASCENT TABLES (PREOXYGENATION TIMES)

M N2 15 *	469	454	438	423	407	392	376	361	345	329	313	297	279	261	241	217	188	150
ALTITUDE IN THOUSANDS OF FEET	22.1	22.8	23.6	24.4	25.2	26.0	26.9	27.3	28.7	29.6	30.6	31.5	32.7	33.8	34.9	36.1	37.4	38.7
TOTAL PRESSURE	320	310	300	290	280	270	260	250	240	230	220	210	200	190	180	170	160	150
PI N2 15(MM HG)																		
600	153	173	195	217	241	264	290	315	344	374	405	438	477	520	571	638	731	879
590	142	162	185	206	230	254	280	305	333	363	395	428	467	509	560	627	720	869
580	132	152	174	196	220	243	269	295	323	353	384	417	457	499	550	617	710	858
570	121	141	163	185	209	232	258	284	312	342	373	406	446	488	539	606	699	847
560	110	130	152	174	198	221	247	273	301	331	362	395	435	477	528	595	688	836
550	99	119	141	163	187	210	236	262	290	320	351	384	424	466	517	584	677	825
540	88	108	130	152	176	199	225	250	279	309	340	373	413	455	506	573	666	814
530	76	96	118	140	164	188	214	239	267	297	328	362	401	443	494	561	654	802
520	64	84	107	128	152	176	202	227	256	285	317	350	389	432	482	550	642	791
510	52	72	95	116	140	164	190	215	244	273	305	338	377	420	470	538	630	779
500	40	60	83	104	128	152	178	203	231	261	292	326	365	407	458	525	618	766
490	29	48	70	92	116	139	165	190	219	249	280	313	353	395	446	513	606	754
480	15	35	57	79	103	126	152	178	206	236	267	300	340	382	433	500	593	741
470	2	22	44	66	90	113	139	165	193	223	254	287	327	369	420	487	580	728
460	0	9	31	53	77	100	126	151	180	210	241	274	313	356	407	474	566	715
450	0	0	17	39	63	86	112	138	166	196	227	260	300	342	393	460	553	701
440	0	0	3	25	49	72	98	124	152	182	213	246	286	328	379	446	539	687
430	0	0	0	11	35	58	84	110	138	168	199	232	272	314	365	432	525	673
420	0	0	0	0	20	43	69	95	123	153	184	217	257	299	350	417	510	658
410	0	0	0	0	5	28	54	80	108	138	169	202	242	284	335	402	495	643
400	0	0	0	0	0	13	39	65	93	123	154	187	227	269	320	387	480	628
390	0	0	0	0	0	0	23	49	77	107	138	171	211	253	304	371	464	612
380	0	0	0	0	0	0	7	33	61	91	122	155	195	237	288	355	448	596
370	0	0	0	0	0	0	0	16	44	74	105	138	178	220	271	338	431	579
360	0	0	0	0	0	0	0	0	27	57	88	121	161	203	254	321	414	562
350	0	0	0	0	0	0	0	0	10	39	71	104	143	186	236	304	396	545
340	0	0	0	0	0	0	0	0	0	21	52	86	125	167	218	285	378	526
330	0	0	0	0	0	0	0	0	0	2	34	67	106	149	199	267	359	508
320	0	0	0	0	0	0	0	0	0	0	14	47	87	129	180	247	340	488
310	0	0	0	0	0	0	0	0	0	0	0	28	67	109	160	227	320	468
300	0	0	0	0	0	0	0	0	0	0	0	7	46	89	139	207	299	448
290	0	0	0	0	0	0	0	0	0	0	0	0	25	67	118	185	278	426
280	0	0	0	0	0	0	0	0	0	0	0	0	3	45	96	163	256	404
270	0	0	0	0	0	0	0	0	0	0	0	0	0	22	73	140	233	381
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	116	209	357
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	91	184	332
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	158	306
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	131	279
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	102	250
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	221
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41	189
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	156
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	83
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 60 MIN. FLIGHT TIME AT TARGET ALTITUDE.

TABLE VII (Cont'd)

ASCENT TABLES (PREOXYGENATION TIMES)

M N2 15 *	727	711	694	678	662	645	629	613	596	580	564	547	531	515	498	482	466	449
ALTITUDE IN THOUSANDS OF FEET	11.1	11.7	12.2	12.7	13.3	13.8	14.4	14.9	15.4	16.1	16.7	17.3	18.0	18.6	19.3	20.0	20.7	21.4
TOTAL PRESSURE PI N2 15(MM HG)	500	490	480	470	460	450	440	430	420	410	400	390	380	370	360	350	340	330
600	0	0	0	0	0	0	0	0	5	21	39	57	76	95	115	136	156	180
590	0	0	0	0	0	0	0	0	0	11	28	47	65	84	105	125	146	169
580	0	0	0	0	0	0	0	0	0	0	18	37	55	74	95	115	136	159
570	0	0	0	0	0	0	0	0	0	0	7	26	44	63	84	104	125	148
560	0	0	0	0	0	0	0	0	0	0	0	15	33	52	73	93	114	137
550	0	0	0	0	0	0	0	0	0	0	0	4	22	41	62	82	103	126
540	0	0	0	0	0	0	0	0	0	0	0	0	11	30	50	71	92	115
530	0	0	0	0	0	0	0	0	0	0	0	0	0	18	39	59	80	103
520	0	0	0	0	0	0	0	0	0	0	0	0	0	6	27	47	68	91
510	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	35	56	79
500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	23	44	67
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	32	55
480	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	42
470	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	29
460	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
440	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
330	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 120 MIN. FLIGHT TIME AT TARGET ALTITUDE.

TABLE VII (Cont'd)

ASCENT TABLES (PREOXYGENATION TIMES)

M N2 15 *	433	417	400	384	368	351	335	319	302	286	270	253	237	220	203	186	168	150
ALTITUDE IN THOUSANDS OF FEET	22.1	22.8	23.6	24.4	25.2	26.0	26.9	27.3	28.7	29.6	30.6	31.5	32.7	33.8	34.9	36.1	37.4	38.7
TOTAL PRESSURE	320	310	300	290	280	270	260	250	240	230	220	210	200	190	180	170	160	150
PI N2 15(MM HG)																		
600	202	225	251	277	303	333	362	393	427	462	498	540	581	629	681	737	804	879
590	192	215	241	266	293	323	352	383	417	451	488	529	571	619	670	727	794	869
580	181	205	230	256	283	312	341	372	407	441	477	519	560	608	660	717	783	858
570	170	194	220	245	272	301	331	361	396	430	467	508	550	597	649	706	772	847
560	160	183	209	234	261	290	320	350	385	419	456	497	539	586	638	695	762	836
550	148	172	198	223	250	279	309	339	374	408	445	486	528	575	627	684	750	825
540	137	161	186	212	238	268	297	328	363	397	433	475	516	564	616	673	739	814
530	126	149	175	200	227	257	286	316	351	385	422	463	505	553	604	661	728	802
520	114	137	163	189	215	245	274	305	339	374	410	451	493	541	593	649	716	791
510	102	125	151	177	203	233	262	293	327	362	398	439	481	529	581	637	704	779
500	90	113	139	164	191	221	250	281	315	349	386	427	469	517	568	625	692	766
490	77	101	126	152	178	208	237	268	302	337	373	415	456	504	556	613	679	754
480	64	88	114	139	166	195	225	255	290	324	361	402	444	491	543	600	666	741
470	51	75	101	126	153	182	211	242	277	311	348	389	431	478	530	587	653	728
460	38	61	87	113	139	169	198	229	263	298	334	376	417	465	517	573	640	715
450	24	48	74	99	126	155	185	215	250	284	321	362	404	451	503	560	626	701
440	10	34	60	85	112	141	171	201	236	270	307	348	390	437	489	546	612	687
430	0	20	45	71	97	127	156	187	222	256	292	334	375	423	475	532	598	673
420	0	5	31	56	83	112	142	172	207	241	278	319	361	408	460	517	584	659
410	0	0	16	41	68	97	127	157	192	226	263	304	346	393	445	502	569	643
400	0	0	0	26	53	82	111	142	177	211	247	289	330	378	430	487	553	629
390	0	0	0	10	37	66	96	126	161	195	232	273	315	362	414	471	537	612
380	0	0	0	0	21	50	79	110	145	179	215	257	298	346	398	455	521	596
370	0	0	0	0	4	33	63	93	128	162	199	240	282	329	381	438	505	579
360	0	0	0	0	0	16	46	76	111	145	182	223	265	312	364	421	487	562
350	0	0	0	0	0	0	28	59	93	128	164	205	247	295	347	403	470	545
340	0	0	0	0	0	0	10	41	75	109	146	187	229	277	328	395	452	526
330	0	0	0	0	0	0	0	22	56	91	127	168	210	258	310	366	433	508
320	0	0	0	0	0	0	0	2	37	71	108	149	191	238	290	347	414	498
310	0	0	0	0	0	0	0	0	17	51	88	129	171	219	270	327	394	468
300	0	0	0	0	0	0	0	0	0	31	67	108	150	198	250	306	373	448
290	0	0	0	0	0	0	0	0	0	9	46	87	129	176	228	285	352	426
280	0	0	0	0	0	0	0	0	0	0	24	65	107	154	206	263	329	404
270	0	0	0	0	0	0	0	0	0	0	0	42	84	131	183	240	306	381
260	0	0	0	0	0	0	0	0	0	0	0	18	60	107	159	216	282	357
250	0	0	0	0	0	0	0	0	0	0	0	0	35	82	134	191	257	332
240	0	0	0	0	0	0	0	0	0	0	0	0	9	56	108	165	231	306
230	0	0	0	0	0	0	0	0	0	0	0	0	0	29	81	138	204	279
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	109	176	250
210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	79	146	221
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	114	189
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	81	156
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	121
170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	83
160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

MINIMUM OF OXYGEN BREATHING AT SEALEVEL REQUIRED TO ATTAIN INDICATED ALTITUDE BY DIRECT ASCENT.
* TO YIELD ACCEPTABLE RISK FOR 120 MIN. FLIGHT TIME AT TARGET ALTITUDE.

IV. ADMINISTRATIVE INFORMATION

The work reported herein was performed by Messers. P. L. Kelley, N. Skalski and E. L. Smith, Jr. of the Niagara Frontier Regional Computer Center of Union Carbide Corporation at Tonawanda, N. Y. and by Dr. H. R. Schreiner, the Principal Investigator. Dr. Schreiner is currently Director of Research and Development of Ocean Systems, Inc., an affiliate of Union Carbide Corporation and the Singer Company. He is located at the Tarrytown Technical Center, Saw Mill River Road at Route 100C, Tarrytown, New York 10591, Telephone (914) 345-3029.

APPENDIX I

Objectives and Procedures of Computer
Analyses No. 12 - 15

Analysis No. 12

Objective: To assess the distribution of maximum values of $\pi^{15}_{N_2}$ sustained in each 50-mm Hg range of total pressure.

Execution: Determine the highest value of calculated dissolved nitrogen pressure in the 15th tissue compartment ($\pi^{15}_{N_2}$) experienced at any discontinuity or at the moment of the first reported "hit" for each nitrogen flight. In each 50-mm Hg pressure range (400-350, 350-300, 300-250, 250-200, and 200-150) tabulate the values of $\pi^{15}_{N_2}$ in increasing order of magnitude, and indicate for each entry the character of the flight ("hit" or "no hit"). If the first "hit" was sustained within the pressure range for which the tabulation is made, show the "hit" score as well. If the first "hit" of a "hit" flight did not occur in the pressure range for which the tabulation is made, show the total pressure at which the first hit was reported.

In each pressure range present for each entry the flight number and a running tally of (1) all entries with a "hit" within the pressure range in question, and of (2) all entries in that pressure range.

Definition: "Hit" flights are considered "clean" until the first report of a "hit" score of 2 or higher, except that if the highest "hit" score attained throughout the flight is 2, the flight is considered to be a "no hit" flight.

Conduct this analysis (1) for the 1006 new flights, (2) for all nitrogen flights on hand (315 + 1006 = 1321).

Analysis No. 13

Objective: To assess the distribution of maximum values of $\pi^{15}_{N_2}$ sustained in each 50-mm Hg range of total pressure.

Execution: Determine the highest value of calculated dissolved nitrogen pressure in the 15th tissue compartment ($\pi^{15}_{N_2}$) experienced at any discontinuity or at the moment of the first reported "hit" for each nitrogen flight. In each 50-mm Hg pressure range (400-350, 350-300, 300-250, 250-200, and 200-150) tabulate the values of $\pi^{15}_{N_2}$ in increasing order of magnitude, and indicate for each entry the character of the flight ("hit" or "no hit"). If the first "hit" was sustained within the pressure range for which the tabulation is made, show the "hit" score as well. If the first "hit" of a "hit" flight did not occur in the pressure range for which the tabulation is made, show the total pressure at which the first hit was reported.

In each pressure range present for each entry the flight number and a running tally of (1) all entries with a "hit" within the pressure range in question and of (2) all entries in that pressure range.

Definition: "Hit" flights are considered "clean" until the first report of a "hit" score of 3 or higher, except that if the highest "hit" score attained throughout the flight is 3, the flight is considered to be a "no hit" flight.

Conduct this analysis (1) for the 1006 new flights, (2) for all nitrogen flights on hand (315 + 1006 = 1321).

Analysis No. 14

Objective: To assess the distribution of maximum values of $\pi^{15}_{N_2}$ sustained in each 50 mm Hg range of total pressure.

Execution: Determine the highest value of calculated dissolved nitrogen pressure in the 15th tissue compartment($\pi^{15}_{N_2}$) experienced at any discontinuity or at the moment of the first reported "hit" for each nitrogen flight. In each 50 mm Hg pressure range (400-350, 350-300, 300-250, 250-200, and 200-150), tabulate the values of $\pi^{15}_{N_2}$ in increasing order of magnitude, and indicate for each entry the character of the flight ("hit" or "no hit"). If the first "hit" was sustained within the pressure range for which the tabulation is made, show the "hit" score as well. If the first "hit" of a "hit" flight did not occur in the pressure range for which the tabulation is made, show the total pressure at which the first hit was reported.

In each pressure range present for each entry the flight number and a running tally of (1) all entries with a "hit" within the pressure range in question and of (2) all entries in that pressure range.

Ignore all flights with a residence time at target pressure of 0-15 minutes.

Definition: "Hit" flights are considered "clean" until the first report of a "hit" score of 2 or higher, except that if the highest "hit" score attained throughout the flight is 2, the flight is considered to be a "no hit" flight.

Conduct this analysis for all 1321 nitrogen flights on hand.

Analysis No. 15

Objective: To assess the distribution of maximum values of $\pi^{15}_{N_2}$ sustained in each 50 mm Hg range of total pressure.

Execution: Determine the highest value of calculated dissolved nitrogen pressure in the 15th tissue compartment ($\pi^{15}_{N_2}$) experienced at any discontinuity or at the moment of the first reported "hit" for each nitrogen flight. In each 50 mm Hg pressure range (400-350, 350-300, 300-250, 250-200, and 200-150), tabulate the values of $\pi^{15}_{N_2}$ in increasing order of magnitude, and indicate for each entry the character of the flight ("hit" or "no hit"). If the first "hit" was sustained within the pressure range for which the tabulation is made, show the "hit" score as well. If the first "hit" of a "hit" flight did not occur in the pressure range for which the tabulation is made, show the total pressure at which the first hit was reported.

In each pressure range present for each entry, the flight number and a running tally of (1) all entries with a "hit" within the pressure range in question and of (2) all entries in that pressure range.

Ignore all flights with a residence time at target pressure of 0-30 minutes.

Definition: "Hit" flights are considered "clean" until the first report of a "hit" score of 2 or higher, except that if the highest "hit" score attained throughout the flight is 2, the flight is considered to be a "no hit" flight.

Conduct this analysis for all 1321 nitrogen flights on hand.

APPENDIX II

Objectives and Procedures of
Computer Analysis No. 16

Analysis No. 16

Objective: To assess the effect of time at target pressure on the rate of incidence of decompression sickness.

Execution: Determine the highest value of calculated dissolved nitrogen pressure in the 15th tissue compartment ($\pi^{15}_{N_2}$) at the moment of arrival of each flight at its maximum altitude (target pressure). Within each 50 mm Hg range of target pressure (400-350, 350-300, 300-250, 250-200, and 200-150) group all flights in terms of the recorded values of $\pi^{15}_{N_2}$ on arrival at target pressure and display as a function of time of residence at target pressure, (0-5, 5-15, 15-25, 25-35, 35-45, 45-55, 55-65, 65-75, 75-85, 85-95, 95-105, 105-115, 115-125, 125-135, and 135+ minutes) the following information: number of flights in being, number of "hits", number of flights withdrawn without sustaining "hits" (number of programmed drop outs), cumulative percentage of "hits" and percentage of hits within each time interval of residence at target pressure.

Definition: "Hit" flights are considered "clean" until the first report of a "hit" score of 2 or higher, except that if the highest "hit" score attained throughout the flight is 2, the flight is considered to be a "no hit" flight.

Conduct this analysis for all 1553 nitrogen flights on hand.

APPENDIX III

Results of Linear Regression Programs

MVFT 10, MVFT 60 and MVFT 120

SELECTION..... 1

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	352.50000	276.48071	0.96961	1.25339	0.01151	108.87602
3	0.74510	0.49681	0.69438	237.06035	6.40666	37.00215
DEPENDENT						
2	580.50000	417.80493				

INTERCEPT -37.95288

MULTIPLE CORRELATION 0.99998

STD. ERROR OF ESTIMATE 4.78278

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	523660.12500	261830.06250	11446.12109
DEVIATION FROM REGRESSION	1	22.87500	22.87500	
TOTAL	3	523683.00000		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.68115	0.31885
2	540.00000	543.48682	-3.48682
3	480.00000	476.77710	3.22290
4	150.00000	150.05508	-0.05508

MULTIPLE REGRESSION.....MVFT60

SELECTION......1

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS. Y	REGRESSION COEFFICIENT	STD. ERROR OF REG. COEF.	COMPUTED T VALUE
1	395.00000	322.21875	0.99890	1.55037	0.00206	751.20117
3	0.66624	0.57698	0.69379	56.27588	1.15257	48.82663
DEPENDENT						
2.	567.33325	521.53735				

INTERCEPT -82.55420

MULTIPLE CORRELATION 1.00000

STD. ERROR OF ESTIMATE 0.70711

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	544002.06250	272001.00000	544002.00000
DEVIATION FROM REGRESSION	0	0.50000	0.50000	
TOTAL	2	544002.56250		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.99927	0.00073
2	400.00000	400.00024	-0.00024
3	150.00000	150.00061	-0.00061

MULTIPLE REGRESSION.....MFT120

SELECTION..... 1

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	395.00000	322.21875	0.99999	1.63297	0.00206	791.22795
3	0.66624	0.57692	-0.66294	5.88501	1.15257	5.10601
DEPENDENT						
2	554.00000	528.42017				

INTERCEPT -94.94432

MULTIPLE CORRELATION 1.00000

STD. ERROR OF ESTIMATE 0.70711

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	558455.50000	279227.75000	558455.50000
DEVIATION FROM REGRESSION	0	0.50000	0.50000	
TOTAL	2	558456.00000		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.99902	0.00098
2	360.00000	360.00000	0.0
3	150.00000	150.00108	-0.00108

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	352.50000	276.48071	0.96961	1.25339	0.01151	108.87602
3	0.74510	0.49681	0.69438	237.06035	6.40666	37.00215
DEPENDENT						
2	580.50000	417.80493				

INTERCEPT -37.95288

MULTIPLE CORRELATION 0.99998

STD. ERROR OF ESTIMATE 4.78276

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	523660.12500	261830.06250	11446.12109
DEVIATION FROM REGRESSION	1	22.87500	22.87500	
TOTAL	3	523683.00000		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.68115	0.31885
2	540.00000	543.48682	-3.48682
3	480.00000	476.77710	3.22290
4	150.00000	150.05508	-0.05508

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMPUTED T VALUE
1	395.00000	322.21875	0.99890	1.55037	0.00206	751.20117
3	0.66624	0.57698	0.69379	55.27588	1.15257	45.82663
DEPENDENT						
2	567.33325	521.53735				

INTERCEPT -82.55420

MULTIPLE CORRELATION 1.00000

STD. ERROR OF ESTIMATE 0.70711

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	544002.06250	272001.00000	544002.00000
DEVIATION FROM REGRESSION	0	0.50000	0.50000	
TOTAL	2	544002.56250		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.99927	0.00073
2	400.00000	400.00024	-0.00024
3	150.00000	150.00061	-0.00061

MULTIPLE REGRESSION.....MET120

SELECTION..... 1

VARIABLE NO.	MEAN	STANDARD DEVIATION	CORRELATION X VS Y	REGRESSION COEFFICIENT	STD. ERROR OF REG.COEF.	COMP T VA
1	395.00000	322.21875	0.99999	1.63297	0.00206	791.22
3	0.66624	0.57698	0.66294	5.88501	1.15257	5.10
DEPENDENT						
2	554.00000	528.42017				

INTERCEPT -94.94482

MULTIPLE CORRELATION 1.00000

STD. ERROR OF ESTIMATE 0.70711

ANALYSIS OF VARIANCE FOR THE REGRESSION

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F VALUE
ATTRIBUTABLE TO REGRESSION	2	558455.50000	279227.75000	558455.50000
DEVIATION FROM REGRESSION	0	0.50000	0.50000	
TOTAL	2	558456.00000		

TABLE OF RESIDUALS

CASE NO.	Y VALUE	Y ESTIMATE	RESIDUAL
1	1152.00000	1151.99902	0.00098
2	360.00000	360.00000	0.0
3	150.00000	150.00108	-0.00108

END

DATE

FILMED

JUL 22 1970