APPENDIX A

Derivation of MK 15/16 0.7 ATA Fixed PO_2 in Nitrogen Decompression Model Gas Uptake And Elmination Equations

INTRODUCTION

The MK 15 Decompression Model evolved in two phases. The first phase was the so called Exponential-Exponential or E-E Model. In principle, this is the model which had been used to compute existing U.S. Navy Air Tables. The concepts of the E-E Model have been well documented and appropriate references are cited in Reference 1 of the main text. This model was used in Phase I of the MK 15 Decompression Algorithm development and assumes gas always remains in solution and that gas uptake and elimination are described as exponential functions. The E-E Model was eventually discarded in favor of the Exponential-Linear or E-L Model. In this model, gas uptake remains exponential but during desaturation offgassing becomes linear when tissue tension exceeds ambient pressure. Derivation of the E-E Model will be discussed first followed by derivation of the E-L Model.

EXPONENTIAL-EXPONENTIAL (E-E) MODEL

The body is assumed to be mathematically equivalent to 9 tissues, each one distinguished from the other by the blood flow per unit volume ($\dot{Q}/V$). These tissues are not necessarily anatomically distinguishable and the same anatomical regions of the body may be composed of several of these tissues. Each of these tissues is assumed to take up and give off gas independently of each other and to be well stirred, that is the gas concentration is the same throughout. It is further assumed in the E-E Model that arterial and inspired oxygen tension are the same. Conceptually, the E-E Model is presented in the top portion of Fig. A-1. Using a mass balance equation, the rate of accumulation of gas in any tissue at any given time is the difference between the rate at which gas enters and leaves the compartment:

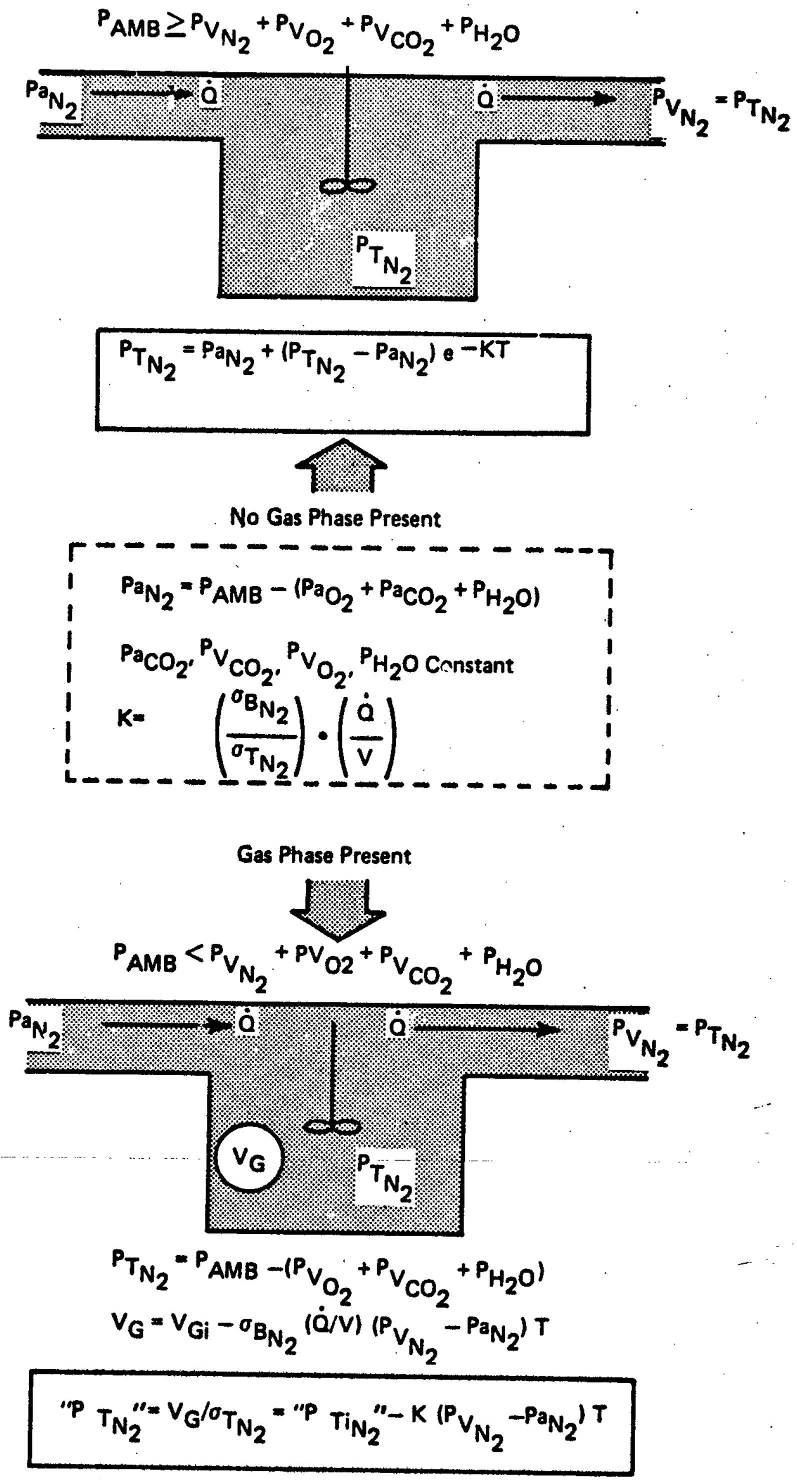

FIGURE A-1. Conceptual representation of gas uptake and elimination equations. The E-E Model uses the scheme in the top of the figure in which there is no gas phase for gas uptake or elimination. The E-L Model uses the scheme in the top portion for gas uptake and the lower scheme for gas elimination, where a gas phase is present when total tissue gas tension exceeds ambient. SEE TEXT FOR SYMBOL DEFINITIONS.

(1-A) $\dot{V} = (C_a - C_v) \cdot \dot{O}$

where:

C_a = arterial gas concentration

C_v = venous gas concentration

$\dot{O}$ = blood flow per unit tissue volume

$\dot{V}$ = rate of gas accumulation

Gas concentration can be related to partial pressure by Henry's law:

(2-A) $C = P \cdot \sigma$

where:

P = partial pressure

σ = solubility

Substituting this into Equation 1-A:

(3-A) $\dot{V} = (P_{a_{N_2}} - P_{v_{N_2}}) \cdot \sigma_{B_{N_2}} \cdot \dot{Q}$

where:

$P_{a_{N_2}}$ = arterial nitrogen partial pressure

$P_{v_{N_2}}$ = venous nitrogen partial pressure

$\sigma_{B_{N_2}}$ = blood nitrogen solubility

The rate of gas volume accumulation can be written as a rate of partial pressure change times tissue solubility. Furthermore, the tissue partial pressure ($P_{T_{N_2}}$) and venous partial pressure ($P_{v_{N_2}}$) are assumed to be the same so Equation 3-A becomes:

$$\dot{P}_{T_{N_2}} \cdot \sigma_{T_{N_2}} = (P_{a_{N_2}} - P_{T_{N_2}}) \cdot \sigma_{B_{N_2}} \cdot \dot{Q}$$

rearranging:

$$(4\text{-A})\quad \dot{P}_{T_{N_2}} = (P_{a_{N_2}} - P_{T_{N_2}})(\sigma_{B_{N_2}}/\sigma_{T_{N_2}})\cdot\dot{Q}$$

where:

$\dot{P}_{T_{N_2}}$ = rate of change of tissue or venous nitrogen partial pressure

$P_{T_{N_2}}$ = tissue or venous nitrogen partial pressure

$\sigma_{T_{N_2}}$ = tissue nitrogen solubility

Now assume that the arterial inert gas partial pressure changes linearly:

$$(5\text{-A})\quad P_{a_{N_2}} = P_{ai_{N_2}} + R_{N_2}\cdot T$$

$P_{ai_{N_2}}$ = arterial inert gas pressure at start of depth change

R_{N_2} = rate of inert gas partial pressure change

T = time from beginning of depth change

Substituting Equation 5-A into Equation 4-A:

$$(6\text{-A})\quad \dot{P}_{T_{N_2}} = (P_{ai_{N_2}} + R_{N_2}\cdot T - P_{T_{N_2}})\cdot K$$

where

$$K = (\sigma_{B_{N_2}}/\sigma_{T_{N_2}})\cdot\dot{Q}$$

Equation 6-A is a first order linear differential equation which can be solved using an integrating factor. The solution is:

$$(7\text{-A}) \quad P_{T_{N_2}} = P_{ai_{N_2}} \cdot (1-e^{-K \cdot T}) + P_{Ti_{N_2}} \cdot e^{-K \cdot T} + R_{N_2} \cdot T + (R_{N_2}/K)(e^{-K \cdot T}-1)$$

where:

$P_{Ti_{N_2}}$ = initial tissue or venous nitrogen tension

If the inert gas partial pressure is changed as a step function, R_{N_2} will be 0 and Equation 7-A will become (with rearranging):

$$(8\text{-A}) \quad P_{T_{N_2}} = P_{a_{N_2}} + (P_{Ti_{N_2}} - P_{a_{N_2}}) \cdot e^{-K \cdot T}$$

with the arterial nitrogen tension after the step change ($P_{a_{N_2}}$) being substituted for $P_{ai_{N_2}}$.

It is Equation 8-A which is used to represent gas uptake and elimination for each tissue in the real time E-E algorithm. $P_{T_{N_2}}$ is evaluated at 2 sec intervals and becomes the value of $P_{Ti_{N_2}}$ for the next iteration. Thus, the dive is approximated as a series of 2 second "stairs" each having an instantaneous depth change. Equation 7-A is used to compute the gas tensions for linear ascents and descents and was used to compute decompression tables in Appendix D as described in Reference 5.

EXPONENTIAL-LINEAR (E-L) MODEL

In the E-L Model, gas uptake is described by Equation 7A for linear ascents or descents or Equation 8-A for a step change. However, in the E-L Model, the arterial inert gas tension and inspired inert gas tension are not equal, but rather:

(9-A) $P_{a_{N_2}} = P_{AMB} - P_{a_{O_2}} - P_{a_{CO_2}} - P_{H_2O}$

where:

$P_{a_{CO_2}}$ = arterial CO_2 tension

$P_{a_{O_2}}$ = arterial O_2 tension

P_{H_2O} = water vapor tension

Arterial O_2 tnesion is assumed equal to inspired O_2 tension and arterial CO_2 tension assumed constant throughout the dives.

Venous and tissue gas tensions are assumed equal as in the E-E model. It is assumed that no supersaturation can take place and that whenever the total venous (or tissue) gas tension exceeds ambient, gas will come out of solution. Thus, a gas phase will form whenever;

$$P_{v_{O_2}} + P_{v_{CO_2}} + P_{v_{N_2}} + P_{H_2O} > P_{AMB}$$

or;

(10-A) $P_{v_{N_2}} > P_{AMB} - (P_{v_{O_2}} + P_{v_{CO_2}} + P_{H_2O})$

where:

$P_{v_{O_2}}$ = venous or tissue oxygen partial pressure

$P_{v_{CO_2}}$ = venous or tissue carbon dioxide partial pressure

Both $P_{v_{O_2}}$ and $P_{v_{CO_2}}$ are assumed to be constant and independent of depth or arterial gas tension.

Once gas comes out of solution and a gas phase forms, diffusion between the gas phase and surrounding tissue is assumed to be instantaneous and the pressure inside of the gas phase exactly equal to ambient hydrostatic pressure. This means that once the gas phase forms, its volume may change but the total tissue gas tension will never exceed ambient. While the gas phase exists, its volume will change according to the arterial venous difference in inert gas times the blood flow, that is:

(11-A) $$\dot{V}_G = \sigma_{B_{N_2}}(P_{a_{N_2}} - P_{v_{N_2}})\cdot\dot{Q}$$

where:

$\dot{V}_G$ = rate of volume change of gas phase

$P_{a_{N_2}}$ = arterial nitrogen tension

$P_{v_{N_2}}$ = venous or tissue nitrogen tension

$\sigma_{B_{N_2}}$ = blood nitrogen solubility

$\dot{Q}$ = blood flow per unit tissue volume

Since arterial gas tensions always add up to total ambient pressure:

(12-A) $$P_{a_{N_2}} = P_{AMB} - (P_{a_{O_2}} + P_{a_{CO_2}} + P_{H_2O})$$

for venous or tissue inert gas tension:

(13-A) $$P_{v_{N_2}} = P_{AMB} - (P_{v_{O_2}} + P_{v_{CO_2}} + P_{H_2O})$$

Substituting Equations 12 and 13 into equation 11:

$$\dot{V}_G = \sigma_{B_{N_2}}\cdot[(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{a_{O_2}}]\cdot\dot{Q}$$

In this model, it is assumed that inspired and arterial oxygen tension are equal, that is, $P_{I_{O_2}} = P_{a_{O_2}}$. Making this substitution:

(14-A) $$\dot{V}_G = \sigma_{B_{N_2}}\cdot[(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{I_{O_2}}]\cdot\dot{Q}$$

The assumption that arterial and inspired oxygen tensions are equal is an oversimplification. A more exact representation of arterial oxygen tension is based on the alveolar gas equation[1]:

$$P_{a_{O_2}} = P_{I_{O_2}} - \{P_{A_{CO_2}}/R - F + AaDO_2\}$$

where:

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

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

R = respiratory quotient

$AaDO_2$ = alveolar-arterial oxygen difference

The terms in { } brackets are depth independent and come to approximately 50 mmHg. Ignoring these terms will over estimate $P_{a_{CO_2}}$ by 50 mmHg which will over estimate the rate of inert gas elimination in Equation 14-A. In the context of all the other assumptions made in deriving the E-L Model, assuming the $P_{I_{O_2}} = P_{a_{O_2}}$ was considered justified in this early phase of development.

At this point, it is useful to pull a little mathematical slight of hand. The left hand portion of equation 14-A represents a volume change. However, this volume could be represented by the product of solubility and partial pressure. This tissue partial pressure ("$P_{T_{N_2}}$") would conceptually

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

be that which would result if the inert gas phase were forced into solution. Making this substitution:

$$\sigma_{T_{N_2}} \cdot \text{"}\dot{P}_{T_{N_2}}\text{"} = \sigma_{B_{N_2}} \cdot [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{I_{O_2}}] \cdot \dot{Q}$$

where:

$\sigma_{T_{N_2}}$ = tissue nitroggen solubility

and rearranging:

$$(15\text{-A}) \quad \text{"}\dot{P}_{T_{N_2}}\text{"} = [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{I_{O_2}}] \, (\sigma_{B_{N_2}} / \sigma_{T_{N_2}}) \cdot \dot{Q}$$

Now the term $(\sigma_{B_{N_2}} / \sigma_{T_{N_2}}) \cdot \dot{Q}$ is the exponential time constant K in the gas equation (see equation 6-A). Also, while equation 15-A is a differential equation its solution is simple for a constant inspired oxygen tension and is:

$$(16\text{-A}) \quad \text{"}P_{T_{N_2}}\text{"} = P_{Ti_{N_2}} + [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{I_{O_2}}] \cdot K \cdot T$$

where

$K = (\sigma_{B_{N_2}} - \sigma_{T_{N_2}}) \cdot \dot{Q}$

T = Time from start of depth change

$P_{I_{N_2}}$ = starting tissue nitrogen tension

Equation 16-A is applicable to a step change or linear depth change since the rate of gas elimination is independent of depth.

Note that once the gas phase forms that the rate of inert gas elimination in Equation 15-A is independent of ambient pressure and a function only of inspired oxygen tension. In the MK 15 and MK 16 closed circuit UBAs the oxygen partial pressure is constant so the rate of gas elimination is constant. If one were breathing air where the inspired oxygen tension changes with depth, Equation 15-A predicts that inert gas elimination will be greater at increased depth. If a linear depth change occurs and the breathing gas is a fixed fraction of oxygen, then $P_{I_{O_2}}$ will not be constant but will be:

$$(17\text{-A})\quad P_{I_{O_2}} = F_{I_{O_2}} \cdot (P_{AMBi} + R_D \cdot T)$$

where:

P_{AMBi} = ambient pressure at start of depth change

R_D = rate of depth change

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

T = time from start of depth change

Substituting this into Equation 15-A:

$$"P_{T_{N_2}}" = [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - F_{I_{O_2}} \cdot P_{AMBi} - F_{I_{O_2}} \cdot R_D \cdot T] \cdot K \cdot T$$

which is a linear differential equation, the solution of which is:

$$(18\text{-A})\quad "P_{T_{N_2}}" = P_{Ti_{N_2}} + [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - F_{I_{O_2}} \cdot P_{AMBi}] \cdot K \cdot T - (K \cdot F_{I_{O_2}} \cdot R_D/2) \cdot T^2$$

[2] Rigorously the difference $P_{AMBi} - PH_2O$ should be used instead of just P_{AMBi} in Equation 17-A. However, as P_{AMBi} increases the effect of this omission is minimized.

Note that the product $F_{I_{O_2}} \cdot P_{AMB}$ is the oxygen partial pressure at the beginning of the depth change and $F_{I_{O_2}} \cdot R_D$ is the rate of oxygen partial pressure change. Making these substitutions:

$$\text{(19-A)} \quad "P_{T_{N_2}}" = P_{Ti_{N_2}} + [(P_{v_{O_2}} + P_{v_{CO_2}} - P_{a_{CO_2}}) - P_{ai_{O_2}}] \cdot K \cdot T - (K \cdot R_{O_2}/2) \cdot T^2$$

where:

$P_{ai_{O_2}} = F_{I_{O_2}} \cdot P_{AMB_0} =$ initial arterial oxygen tension

$R_{O_2} = F_{I_{O_2}} \cdot R_D =$ rate of oxygen partial pressure change

For a constant P_{O_2}, R_{O_2} is equal to 0, $P_{ai_{O_2}}$ equals $P_{a_{O_2}}$, and Equation 19-A reduces to equation 16-A. Also, for a step change in depth, R_{O_2} equals 0 and Equation 16-A can be used.

To summarize, the E-L Model uses the exponential gas uptake Equation 7-A (or 8-A for a step change) and uses Equation 9-A to compute arterial inert gas tension. During tissue offgassing, equation 7-A (or 8-A for a step change) will describe desaturation as long as total tissue gas tension is less than ambient. When total tissue gas tension equals ambient, equation 10-A is satisfied and desaturation will be described by equation 16-A for a constant oxygen partial pressure or equation 19-A for a constant oxygen fraction.

Figure A-1 summarizes the E-L Model. Note that the equations in Figure A-1 are for a step change in ambient pressure. The top portion of **Figure A-1** shows the situation when $P_{AMB} \geq P_{v_{N_2}} + P_{v_{O_2}} + P_{v_{CO_2}} + P_{H_2O}$. This **is a** well stirred compartment with no gas phase. When PAMB $<(P_{v_{N_2}} + P_{v_{O_2}} + P_{v_{CO_2}} + P_{H_2O})$ a gas phase forms and the situation becomes that pictured in the bottom of Figure A-1. Here a gas phase with volume V_G forms in the well stirred compartment which is in instantaneous diffusion equilibrium with the fluid in the compartment. The total gas tension inside the gas phase always equals ambient so that as depth decreases the gas tension will not increase but the physical size of the volume V_G will.

Figure A-2 graphs the changes in gas tension for a step change in ambient pressure. This graph illustrates the situation when the P_{O_2} is constant and only the change in arterial nitrogen tension ($P_{a_{N_2}}$) is shown. $P_{a_{N_2}}$ is related to the ambient partial pressure by Equation 9-A and since $P_{a_{O_2}}$ and $P_{a_{CO_2}}$ are constant, $P_{a_{N_2}}$ and P_{AMB} will always differ by a constant amount. In Figure A-2, at time 0, $P_{a_{N_2}}$ increases instantaneously from P_1 to P_2 and remains at P_2 until time T_O. The solid line shows the exponential gas uptake which occurs in the tissue. At time T_O, $P_{a_{N_2}}$ instantaneously decreases from P_2 to P_1. Note that after time T_O, the venous nitrogen tension, $P_{v_{N_2}}$, exceeds $P_{a_{N_2}}$. This amount is constant and can be found by substituting equation 12-A into equation 13-A to get:

$$P_{v_{N_2}} = P_{a_{N_2}} + (P_{a_{O_2}} + P_{a_{CO_2}}) - (P_{v_{O_2}} + P_{v_{CO_2}})$$

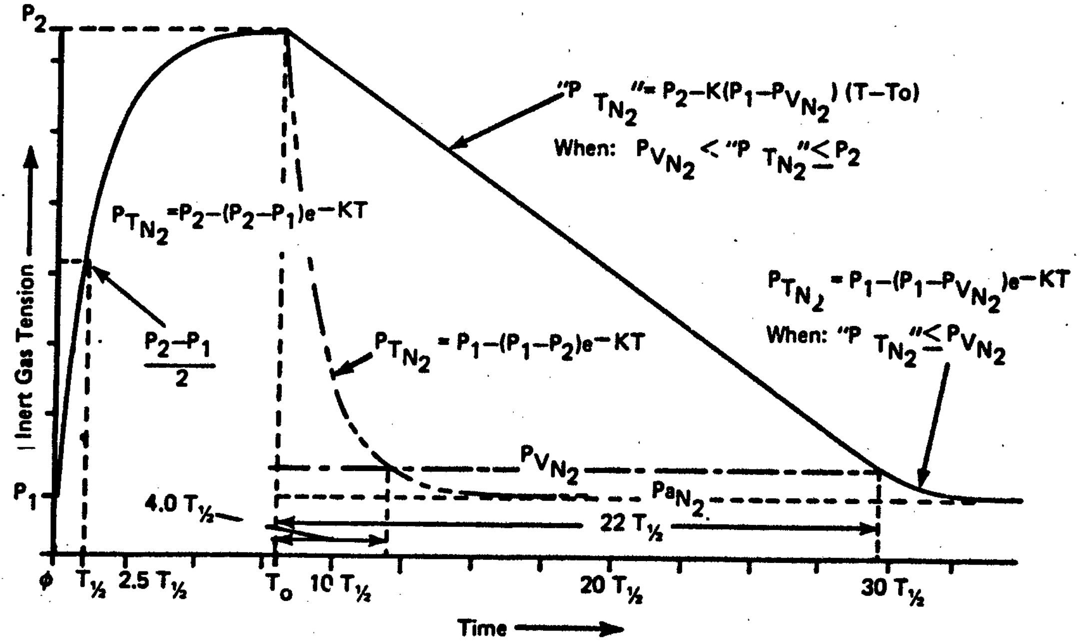

FIGURE A-2. Graphic representation of tissue gas tension for a step change in depth. At time 0, depth increases causing arterial inert gas tension (PaN_2) to decrease from P_1 to P_2. The solid line decreases causing PaN_2 to decreases from P_2 to P_1. The solid line shows tissue gas tension changes according to the E-L Model. The ——— — — ——— dash line shows tissue gas tension decrease according to the E-E Model. The difference $P_2 - P_1$ is exactly 16 times the difference $PvN_2 - PaN_2$ and corresponds to a downward depth excursion of 66 FSW breathing a 0.21 ATA PO_2 gas and 324 FSW if breathing a 0.7 ATA PO_2 gas.

for a PI_{O_2} of 0.7 ATA the arterial tensions will also be 0.7 ATA or expressed in FSW, $Pa_{O_2} = 23.1$ FSW. Pa_{CO_2}, Pv_{O_2} and Pv_{CO_2} are assumed constant and independent of both depth and Pa_{O_2} and are 1.5, 2.0 and 2.3 FSW respectively.[3] Thus:

$$P_{v_{N_2}} = P_{a_{N_2}} + 20.30 \text{ FSW.}$$

This 20.30 FSW arterial-venous nitrogen tension difference is the driving force for inert gas elimination. The actual venous nitrogen tension will fall from P_2 to $P_{v_{N_2}}$ and stay at $P_{v_{N_2}}$ until the entire gas phase is eliminated. The gas phase volume is represented by the dissolved gas tension "$P_{T_{N_2}}$" and this falls linearly according to Equation 16-A. When the dissolved tension "$P_{T_{N_2}}$" equals the venous inert gas tension then the gas phase has been eliminated and the tissue tension will fall from $P_{v_{N_2}}$ to $P_{a_{N_2}}$ exponentially. The double-short/single-long dashed line in Fig. A-2 represents the tissue tension decrease if no inert gas is assumed to form, that is if the E-E Model describes offgassing. Note how much faster gas is eliminated if exponential elimination is assumed than if linear elimination is assumed. This marked assymetry is the main feature of the E-L Model.

In Figure A-2 the ratio between the time it takes tissue inert gas tension to reach $P_{v_{N_2}}$ according to the E-L and E-E Model is 22/4.0 or 5.5. This ratio of times (R) can be expressed in general as:

$$R = (A-1)/LN(A)$$

where:

$$A = (P_2 - P_{a_{N_2}})/(P_{v_{N_2}})$$

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[3] FSW is used to express gas tensions. 33 FSW = 1 ATA = 760 mmHg.

The above equation shows that the increase in offgassing time of the E-L over the E-E Model becomes greater as P_2 gets larger.

The E-L Decompression Model has several inconsistencies and simplifying assumptions. As has been pointed out, assuming $P_{I_{O_2}} = P_{a_{O_2}}$ will cause inert gas elimination rates to be over estimated, and the percentage error will be larger for lower values of $P_{I_{O_2}}$. Another assumption which has been made is that the arterial-venous inert gas tension is independent of arterial oxygen tension. This of course cannot hold over a wide range of arterial oxygen tensions because the hemaglobin dissociation is not linear but sigmoid shaped. These simplifying assumptions were made for the sake of mathematical expediency, their consequences remain to be determined.

TABLE 7

TABLE OF MAXIMUM PERMISSIBLE TISSUE TENSIONS

(WAL10- NITROGEN)

TISSUE HALF-TIMES

Stops in feet | Tensions in FSW

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	110.000	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	134.500	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

Stops in meters | Tensions in FSW

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
3 MSW	120 000	98.000	78.000	56.000	48.500	45.500	44.500	44.000	43.500
6 MSW	129.843	107.843	87.843	65.843	58.343	55.343	54.343	53.843	53.343
9 MSW	139.685	117.685	97.685	75.685	68.185	65.185	64.185	63.685	63.185
12 MSW	149.528	127.528	107.528	85.528	78.028	75.028	74.028	73.528	73.028
15 MSW	159.370	137.370	117.370	95.370	87.870	84.870	83.870	83.370	82.870
18 MSW	169.213	147.213	127.213	105.213	97.713	94.713	93.713	93.213	92.713
21 MSW	179.055	157.055	137.055	115.055	107.355	104.555	103.555	103.055	102.555
24 MSW	188.898	166.898	146.898	124.898	117.398	114.398	113.398	112.898	112.398
27 MSW	198.740	176.740	156.740	134.740	127.240	124.240	123.240	122.740	122.240
30 MSW	208.583	186.583	166.583	144.583	137.083	134.083	133.083	132.583	132.083
33 MSW	218.425	196.425	176.425	154.425	146.925	143.925	142.925	142.425	141.925
36 MSW	228.268	206.268	186.268	164.268	156.768	153.768	152.768	152.268	151.768
39 MSW	238.110	216.110	196.110	174.110	166.610	163.610	162.610	162.110	161.610
42 MSW	247.953	225.953	205.953	183.953	176.453	173.453	172.453	171.953	171.453
45 MSW	257.795	235.795	215.795	193.795	186.295	183.295	182.295	181.795	181.295
48 MSW	267.638	245.638	225.638	203.638	196.138	193.138	192.138	191.638	191.138
51 MSW	277.480	255.480	235.480	213.480	205.980	202.980	201.980	201.480	200.980
54 MSW	287.323	265.323	245.323	223.323	215.823	212.823	211.823	211.323	210.823
57 MSW	297.166	275.165	255.165	233.165	225.665	222.665	221.665	221.165	220.665
60 MSW	307.008	285.008	265.008	243.008	235.508	232.508	231.508	231.008	230.508
63 MSW	316.851	294.851	274.850	252.850	245.350	242.350	241.350	240.850	240.350
66 MSW	326.693	304.693	284.693	262.693	255.193	252.193	251.193	250.693	250.193
69 MSW	336.536	314.536	294.536	272.536	265.036	262.036	261.036	260.536	260.036
72 MSW	346.378	324.378	304.378	282.378	274.878	271.878	270.878	270.378	269.878
75 MSW	356.221	334.221	314.221	292.221	284.721	281.721	280.721	280.221	279.721
78 MSW	366.063	344.063	324.063	302.063	294.563	291.563	290.563	290.063	289.563
81 MSW	375.906	353.906	333.906	311.906	304.406	301.406	300.406	299.906	299.406
84 MSW	385.748	363.748	343.748	321.748	314.248	311.248	310.248	309.748	309.248
87 MSW	395.591	373.591	353.591	331.591	324.091	321.091	320.091	319.591	319.091
90 MSW	405.433	383.433	363.433	341.433	333.933	330.933	329.933	329.433	328.933