

A NEW VPM ALGORITHM FOR REPETITIVE DIVES

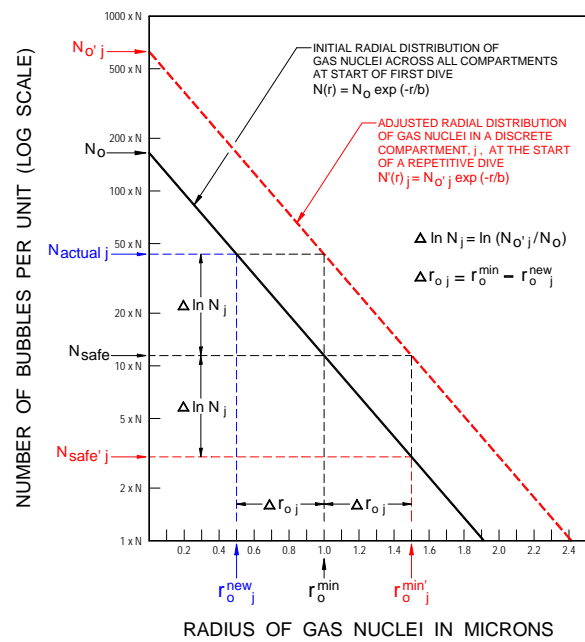
David E. Yount *
University of Hawaii
Honolulu, Hawaii

Eric B. Maiken
n&k Technology, Inc.
Santa Clara, California

Erik C. Baker
Affiliated Engineers SE, Inc.
Gainesville, Florida

* this work is carried out in fond memory of David E. Yount who passed away on April 27th, 2000. David is represented here by his son Steffen Yount.

The concept envisioned by David Yount for repetitive diving calculations:



What does this graph mean?

At the start of a first dive, if the diver has not been diving for a few weeks, the radial distribution of gas nuclei or "bubble seeds" in the body is assumed to be pristine. In other words, the radial distribution is the same in all tissue compartments and has its long-term equilibrium values.

During ascent or decompression on the first dive, the supersaturation gradients in each compartment may be relaxed (increased) by the VPM dynamic critical volume algorithm to allow N_{actual} versus N_{safe} number of bubbles to form. This causes a dispersion in the radial distribution of gas nuclei across the various tissue compartments.

To compensate on a repetitive dive, the new algorithm adjusts the minimum initial radius of gas nuclei in each compartment by an amount proportional to the dispersion that took place on the previous dive.

Its really a very simple concept and it makes sense!

Why is this new algorithm attractive?

- It extends directly from the Varying Permeability Model (VPM) on a fundamental level.
- It avoids the use of ad hoc factors.
- Although the algorithm is pretty green (we have only begun to explore many of its implications), the results so far look promising.

Calculation steps for the new algorithm:

- 1 Calculate the ascent profile for the first dive using the VPM dynamic critical volume algorithm (Yount & Hoffman, 1986). Assume pristine values for all VPM parameters including the minimum initial radius, r_0^{\min} , of gas nuclei to be probed for bubble formation.
- 2 From the maximum supersaturation gradient, $P_{\text{ss}}^{\text{new } j}$, allowed for each compartment on the first dive, calculate the associated value for the new initial radius, $r_0^{\text{new } j}$, of gas nuclei probed for bubble formation in each compartment.
- 3 During the surface interval between dives, track the residual inert gas loading for each compartment in the usual way.
- 4 For the repetitive dive, an adjusted value for the minimum initial radius, $r_0^{\text{min } j}$, of gas nuclei to be probed for bubble formation will be used for each compartment. For short surface intervals, $r_0^{\text{min } j} = r_0^{\min} + \Phi r_{0j}$. For long surface intervals, the regeneration of the pristine radial distribution of gas nuclei may be considered by using the form, $r_0^{\text{min } j} = r_0^{\min} + \Phi r_{0j} \exp(-t_s / \diamond_s)$ where t_s is the surface interval time and \diamond_s is the surface regeneration time constant.
- 5 Calculate the ascent profile for the repetitive dive again using the VPM dynamic critical volume algorithm. This time use the adjusted minimum initial radius, $r_0^{\text{min } j}$, for each compartment and pristine values for all other VPM parameters.

A comparison and some sample profiles:

No-deco limits for 3 days of repetitive air diving - 120 fsw dives, twice a day, with 45 minute surface interval (RGBM profiles courtesy of Bruce R. Wienke):

Computer/Algorithm	Dive 1	Dive 2	Dive 3	Dive 4	Dive 5	Dive 6
Suunto Vyper RGBM	10	6	9	5	9	5
New VPM Algorithm	9	8	8	8	8	8
Decometer RGBM	12	9	10	9	9	9
Technical RGBM	13	11	11	10	10	9

Deep air forward and reverse profiles (depth in fsw / time in min):

Dive 1	Deco 1	Surface Interval	Dive 2	Deco 2
160/7	10/1	30	40/100	10/4
160/7	10/1	60	40/100	10/1
160/7	10/1	120	40/100	no deco
40/100	no deco	30	160/7	30/1, 20/1, 10/3
40/100	no deco	60	160/7	20/1, 10/2
40/100	no deco	120	160/7	20/1, 10/2

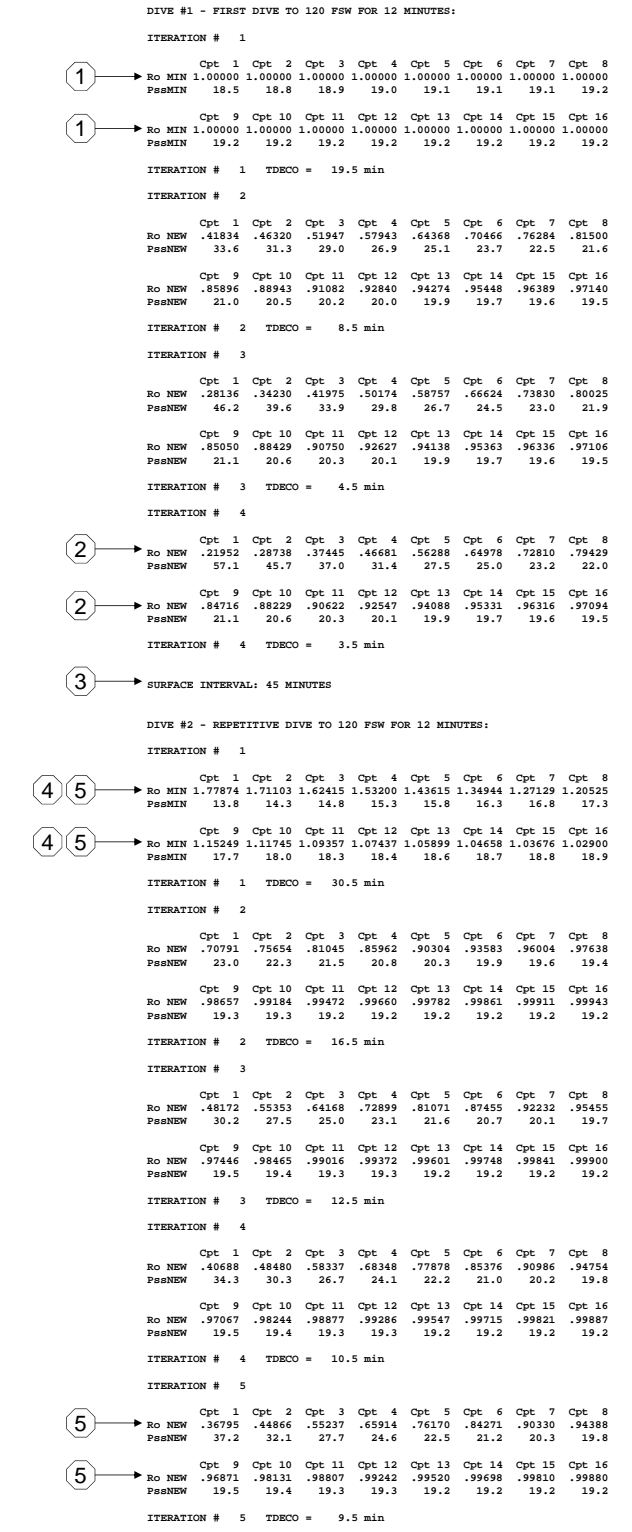
Trimix 16/33 dives to 250 fsw for 30 min. Deco mixes - air at 100 fsw, O₂ at 20 fsw:

Stop	Deco 1	Surface Interval	Deco 2
170	1	120	1
160	1		1
150	1		2
140	2		2
130	2		2
120	2		2
110	3		3
100	2		2
90	2		2
80	2		3
70	4		4
60	4		4
50	5		6
40	7		9
30	10		12
20	8		11
10	12		19

Program output showing how it works:

Sample air dive series

First dive to 120 fsw for 12 minutes (deco 10/2)
Surface interval 45 minutes
Repetitive dive to 120 fsw for 12 min. (deco 30/1, 20/2, 10/5)



Exploring the implications of the new VPM algorithm for repetitive diving:

