

SHORT SUMMARY

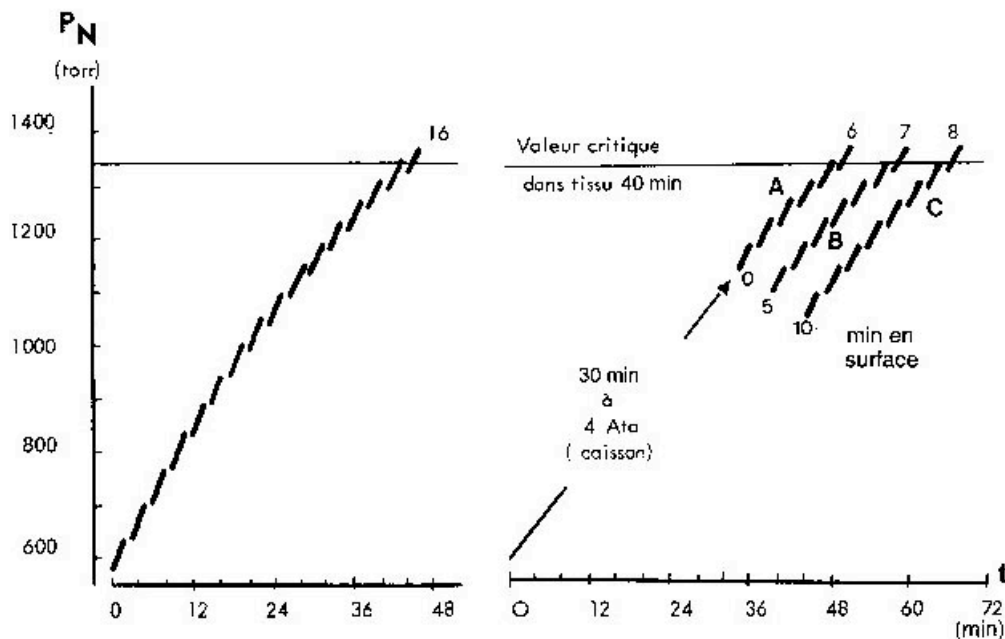
Decompression sickness and freediving

Schaeffer (1955)¹ verified several times the existence of silent bubbles in blood after one fast ascent from 30 meters (non pathological).

Conditions for the appearance of silent bubbles : quick decompression ; ration depth pressure/surface pressure > 3 ; important muscular exercise during the ascent.

Paulev (1965)² showed that decompression accidents like Taravana can arrived after repetitive dives at high frequency, even if the depth is not 30m.

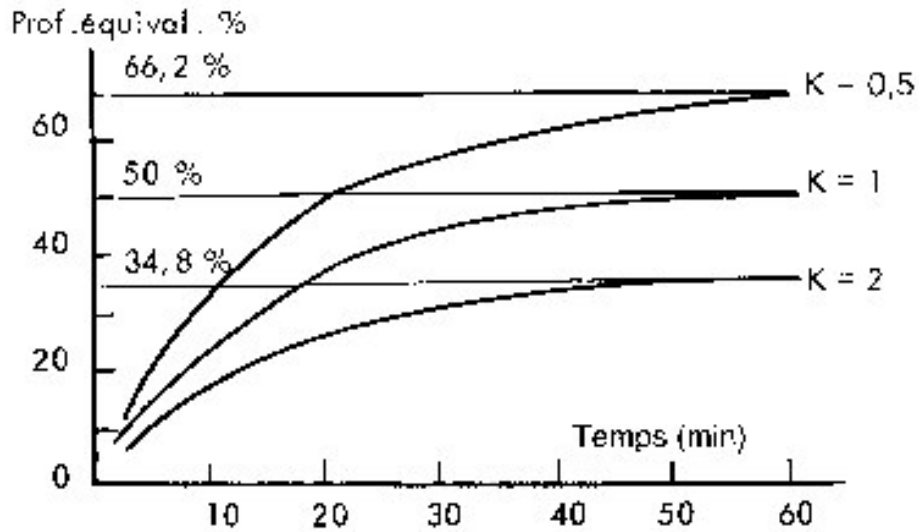
Below, (left part of the picture) example of another experiment realized by Paulev in 1969 to demonstrate that for a tissue which period is 40 minutes, the critical value of N₂ tension is reached after 16 dives at 30 meters (dive time 2', rest at the surface 1'). The right part of the picture demonstrate the same fact but first, the freediver stays 30' in an hyperbaric chamber and after (« A » curve) realize 6 dive to 30m with the following frequency : 2' dive time, 1' surface rest. « B » curve is for surface rest = 5' ; « C » curve is for surface rest = 10'



Lanphier (1965)³ is the first to propose by a calcul a conversion factor to adapt the diving decompression tables to freediving.

The « K » factor is the ratio between surface time and dive time. If $K = 2$, it means that the dive is 1' and the surface rest is 2'. Ascent and descent are considered to be instataneous.

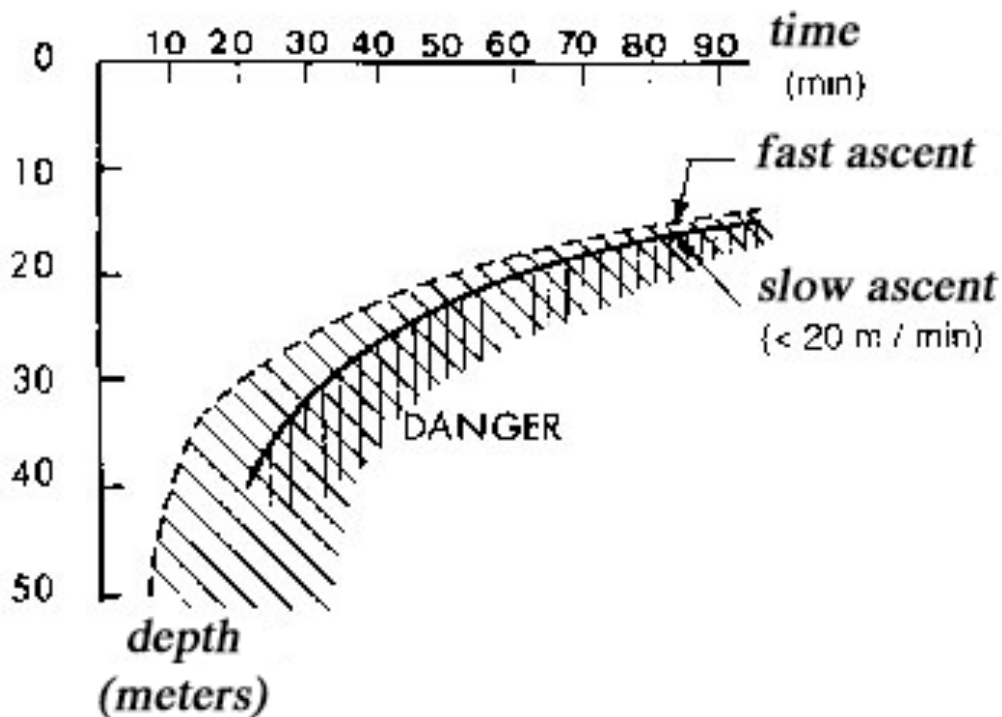
He proposed after his study the picture below (calculated for a tissu : $T = 20'$). The tissu taken into consideration is a good compromise to reflect the whole body behavior. (an intense exercise increase the N₂ gradient between tissus and alveolus and lead to under estimate the equivalent depth : on another side, ascent and descent being not instantaneous this procedure lead to over estimate the equivalent depth). If you know the depth you dive, you use the picture below to determine the max duration of the training.



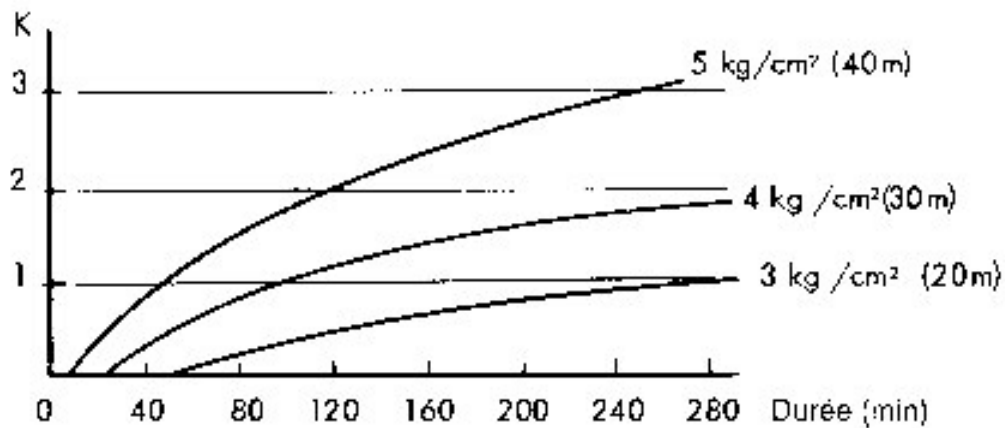
For example 2' rest, 2' dive means $K = 1$. If you go each time at 30 meters, after a training of 60' we have to take a classic decompression table and consider you have dived 60' at 50% of 30m.

BUT, decompression tables are made for a speed ascent = 10 to 15 meters/minute.

The picture below illustrate the 2 different curves we have to take into consideration (safety curve). We can see of course that an important speed ascent increase the risk.



SO, Lanphier (1965) proposed a picture which combined the two above picture and obtain the picture below. Knowing K and depth, we read the max possible training time.



Example : I dive in 40 meters, $K = 2$, max training time is 120 minutes.

Doctor Heran (1991) and Grandjean and coll (1995) worked also in France on this problem. Heran proposed in 1990 a table in which it was possible to determine the max dive number in one hour we should realize, knowing depth, dive time and duration of the training. Picture below :

Pr	t	2 heures	3 heures	4 heures	5 heures
▼	ta	▼ Nombres de plongées ▼			
25 m	1'	37	34	30	29
	2'	18	17	15	14
	3'	12	11	10	9
30 m	1'	31	28	25	24
	2'	15	14	12	12
	3'	10	9	8	8
35 m	1'	26	24	22	20
	2'	13	12	11	10
	3'	9	8	7	7

Example : training duration : 4 hours, dive depth : 30m, 12 dive of 2' per hour : risk of decompression sickness is real.

TRAINING ADVICES

Waiting deep freediving tables (we should find, if they exist, such « Heran's tables » for depth between 40 to 80 meters), we could give the following general advices for trainings :

- Short trainings are better
- Drink water during the training (dehydration increase decompression accidents)
- Be careful with hypothermy (cold help the N₂ saturation)
- Don't practice with fast ascent (In No limit, let the balloon go away at the end of the ascent while you finish by pulling the rope with your hands)
- Take a minimum rest 5', 6' or 7' between your deep dives
- Don't realize the max depth at the end of the training
- Try to go down and up with the maximum relaxed movements you can do (no effort)
- No deep dive when you are tired
- If you feel a little bad after a deep dive, take Oxygene and tell your friends to observe you, if bad sensations persist, go to the hospital

- Use a depth gauge to check and register the frequency of dives (depth, dive time and number in one hour)
- Don't make games with your students at the end of the training with effort and quick ascent (hoping that you'll warm them after they have been cold)
- Planify your training to avoid stupid improvised trainings

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Other reference

Kohshi, K., R. M. Wong, H. Abe, T. Katoh, T. Okudera and Y. Mano (2005). "Neurological manifestations in Japanese Ama divers." Undersea Hyperb Med 32(1): 11-20.

McCrorry, P., E. Matser, R. Cantu and M. Ferrigno (2004). "Sports neurology." Lancet Neurol 3(7): 435-40.

The text considering decompression sickness from a single breath-hold dive was quoted from a chapter in the book "The Lung at Depth". The complete reference is:

Ferrigno, M., and C. E. G. Lundgren. Human breath-hold diving. In: "The lung at depth", edited by C. E. G. Lundgren and J. N. Miller. New York: Marcel Dekker, Inc., p. 529-85, 1999.

Another publication considering this case, as well as some other cases if I remember it correctly, is:

Magno, L., C. E. G. Lundgren, and M. Ferrigno. Neurological problems after breath-hold diving. Undersea and Hyperbaric Medicine Vol. 26 (Supplement): p. 28-29, 1999.

Dr Wong has written two articles in SPUMS (south pacific underwater medical society) and one paper in UHM (2005) together with Kohshi, I suggest you get the UHM paper where you will find many references,

Kohshi K, Wong RM, Abe H, Katoh T, Okudera T, Mano Y.
Neurological manifestations in Japanese Ama divers.
Undersea Hyperb Med. 2005 Jan-Feb;32(1):11-20. Review.

depending when you need to have this finished I might have something interesting, the 2 day symposium this summer (DAN/UHMS) on breath-hold diving included a lot of discussions about DCS in apnea diving, I hope it will be finished for print in dec 2006 (our goal is to get it ready before this year is up).

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