A COMPARATIVE INVESTIGATION OF THE PERFORMANCE, RELIABILITY AND SAFETY OF DIVE COMPUTERS BASED ON SIMULATED AIR-DIVES

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Background/Objective

With multilevel simulations, including repetitive and multi-day, deco-simulations (also deep stop), emergency ascents, yo-yoing, and extreme temperatures, performance of dive computers (**DC**s) was compared mutually, and with DCIEM tables, ZH-L16C %M-values and product specifications.

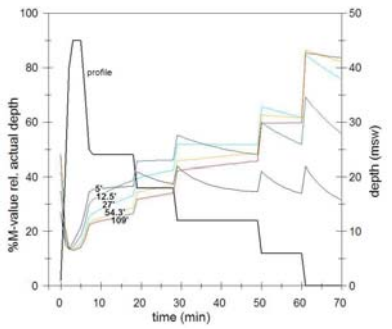

Fig. 1 Calculated %M-values (left axis) of standard simulation (depth on right axis). Numbers are $t_{½}$'s. %M-values are < 100% with the liberal ZH-L16C (shown). RGBM DCs have 0 msw deco-ceilings, but ZH-L8ADT DCs at 3 msw.

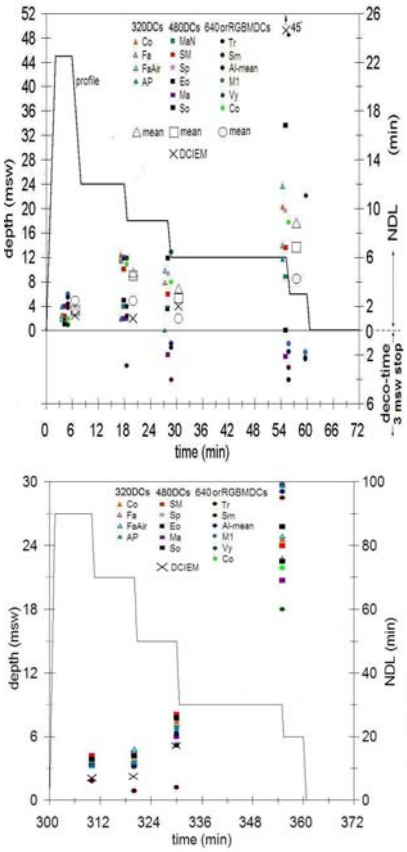

Fig. 2 (a) NDLs (end of each level) and STs at 3 msw (both right axis) of DCs of the 3 classes. STs at 3 msw displayed negatively. On average, 320 DCs are most liberal, 640&RGBM DCs most conservative. The large differences are mainly due to differences in M-values, not to $t_{½}$. (b) With the 27 msw repetitive dive, 320 DCs were on average also most liberal, followed by 480 DCs.

Materials and Methods

In 60 test-chamber sessions, 46 DCs of 29 types (7 fabricates) were examined. No-deco limits (**NDL**s), depths, stop depths and stop times (**STs**), and no-fly times (**NFT**s) were logged (260 simulations). Standard test profiles were realistic and discriminative; maximum diving depth (**MDD**) 45 msw 6 min, total diving time (**TDT**) 60 min (Fig. 1), and after 4 h surface interval 27 msw MDD 10 min, TDT 60 min (Fig. 4), decent and ascent speeds 20 and 10 msw/min. 3 classes of DCs were distinguished: 1. **320DC**s with the highest $t_{½}$ 320 min; 2. 480 DCs with 480 min and no RGBM; 3. 640DCs and RGBM-DCs.)

Results/Discussion

General DC behaviour was not always in accordance with manuals, decompression theory and physiology.
Conservatism NDLs and NFTs of *320- and 480DCs* were (far) *too liberal*, but DCs with RGBM and ZH-L8ADT were more conservative (Fig. 2a&b). With large MDDs, at deep and moderate levels all DCs were more liberal than DCIEM allowed. The shallower the level after a deep 'dive', the larger is the inter-type divergence.
Reproducibility of NDLs is generally (very) good (Fig. 3). Two pre-2000 types failed.
Instabile ("noisy") behaviour of NDL was twice noticed (Fig. 4; pre-2001 types).
Oscillatory behaviour of NDL occurred with 7 DCs (pre-2001 types).
Emergency ascents were corrected during the final ascent by ZH-L8ADT types; other types hardly or *contra-productive*.
Extreme yo-yoing, repetitive (Fig. 5) or with extreme amplitudes (±24, ±18 msw) in 45 msw standard profile, was *not penalized* by RGBM or ZH-L8ADT DCs (once a 2-min increased TDT). Haldanian theory is unsuitable for yo-yoing, but RGBM basically can do.
Refrigeration gives *longer ascent times* with ZH-L8ADT DCs (Uwatec).
Deep stop dives were identical to control dives (despite manual) or *with longer TDT and NFT*.
50% & 100% RGBM settings showed no difference with a 1st dive (Fig. 6), also not with a 2nd dive (27 msw). *RGBM* (mathematics) seems *not implemented in 1st dive* (Suunto, Mares); in successive dives only "f factors"?
Altitude diving and "***personal setting***" is handled identically by most fabricates. This is a questionable method.
NFTs are mostly shorter than the 12-24-36 (48) hour rule, but generally save.

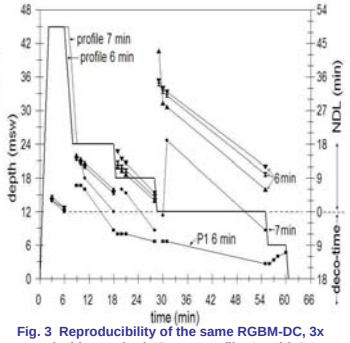

Fig. 3 Reproducibility of the same RGBM-DC, 3x tested with standard 45 msw profile, 1x with P1 setting and 1x with 1 min longer bottom time. Label 'xmin' indicates bottom time. Straight lines between symbols of NDL curves are interpolations.

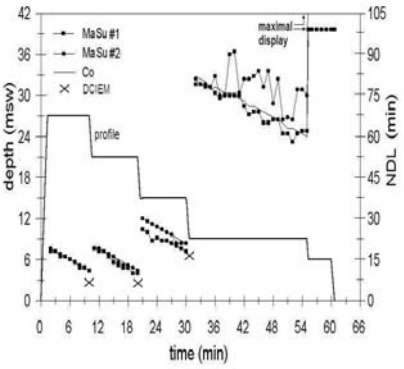

Fig. 4 Instable NDLs (each minute, right axis) during repetitive dive of 2 DCs (MaSu). DC Co behaved regular. DCIEM NDLs presented at the end of each level.

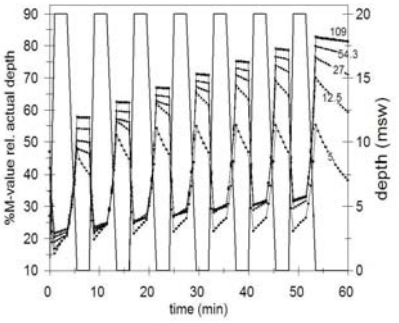

Fig. 5 %M-values calculated for repetitive yo-yo's with ZH-L16C (left axis).

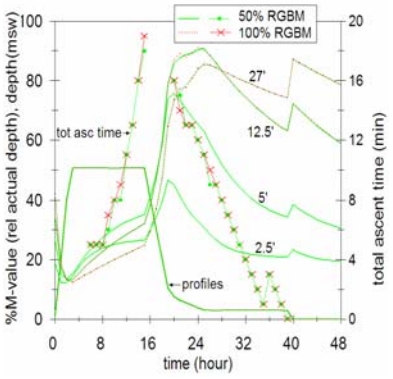

Fig. 6 RGBM-DC with full (100%) and half (50%) "implementation" of RGBM. Left %M-values of ZH-L16C and depth, right total ascent time. After 19 min dive time, 50 and 100% settings yielded identical ascent profiles (as prescribed by DC) and same 'total ascent time' displays. NFT 16h22 and 16h15. The smoothed %M-value curves during the "exponential" ascent (<10 msw; compare with Fig. 1) will diminish bubble occurrence.

Conclusion

Extreme profiles and large aberrations from the usual rules *give large differences* in NDLs and STs, even among RGBM and ZH-L8ADT DCs. RGBM is only partly implemented. Present-day DCs are generally not equipped for handling extreme profiles despite manual-info, but for normal use they are certainly conservative as compared to DCIEM and ZH-L16C. Manuals need improvement (e.g. effect and meaning of "features", procedures, data-retrieval). (www.duikresearch.org)