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THE NOT OBVIOUS OBVIOUSNESS...

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The fact that I have worked as a diving physician for more than 25 years gives me (in my personal opinion) the privilege of sharing with Readers my insights that are not entirely based on scientific principles of phenomena description - although I have always ensured that my publications are based on the principles of EBM (Evidence-Based Medicine). At the same time, however, all true diving enthusiasts realize that there is probably no other such area of human activity, where invariably the better or slightly worse documented insights and principles play such an important role. In diving practice they are usually referred to collectively as "good diving practice" and it so happens that most of them translate to some extent into the safety of diving, including specification of possible adverse consequences for the health and life of the diver.

An excellent example of "good diving practice" is e.g. routine use of the so-called safety stop, or - what is important for the further part of this letter - avoidance of ascending after the so-called decompression edge and constant maintaining (keeping) the diver in a sufficiently high psychophysical condition for diving.

Although the basis for scientific progress is a properly planned experiment, it is sometimes the case that researchers recognise phenomena that are not necessarily related to the substance of the research problem; this is what happened to our team from the Underwater Work Technologies Department (UWTD) of the Naval Academy (AMW) in Gdynia, in the course of one of the stages of the *CRABE* diving apparatus decompression system testing programme, in the *Nx/O₂-SCR SCUBA* configuration within the operating depths range between 0-60 mH_2O.

While the testing of the nitrox-oxygen decompression system itself, based on the new decompression tables dedicated to the *CRABE* diving apparatus, developed by the Project Manager - Ryszard Kłos, Ph.D., professor at AMW, was extremely unproblematic, the team's attention was drawn to the examination results of the experiment's safety divers using air as the main breathing agent and oxygen decompression between the depth of 12 mH_2O and the surface [1]. Owing to the depth and duration of the experimental dive, in the adopted asecuration procedure (dive profile of the safety diver according to the *Table 3 MW* applicable in the Polish Navy) it became necessary to replace the safety divers, at a selected moment of exposure - an example of the profile with the indicated moment of exchange is shown in Fig. 1.

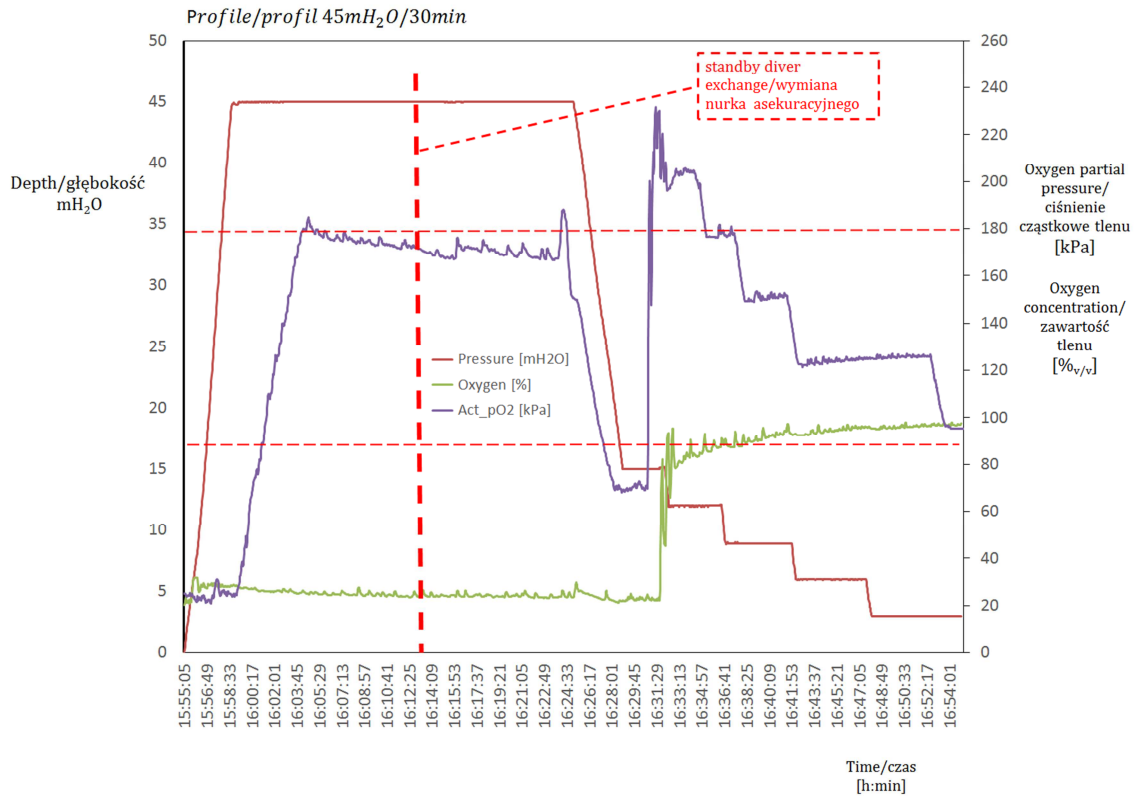
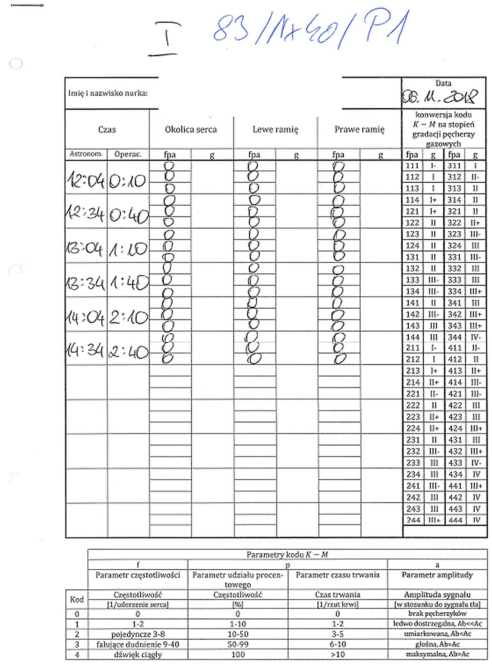


Fig. 1 An example of a dive profile with the indicated moment of exchange of safety divers.

The testing of the decompression system for the *CRABE* diving apparatus included diving exposures with the use of standard NATO nitrox mixtures: 32.5, 40 and 60 %O_2. In order to assess the risk of a decompression sickness (DCS) incident, a well-known and well-proven method of detecting free gaseous phase in divers' venous blood was implemented using CW acoustic Doppler scanner manufactured by Techno Scientific Inc., Canada, which has been successfully used in UWTD of the AMW for nearly 20 years [2]. The measurement result was transferred into the test protocol using the conversion of the acoustic signal into a digital code for the gradation of gas bubbles, proposed by Kisman and Masurel, known more broadly as the *K-M code*. Without going into details, it can be simply assumed that the lower the signal gradation, the smaller the probability of occurrence of DCS - scans of sample protocols from experimental and asecuration dives are presented in Fig. 2 and 3.

(a)



(b)

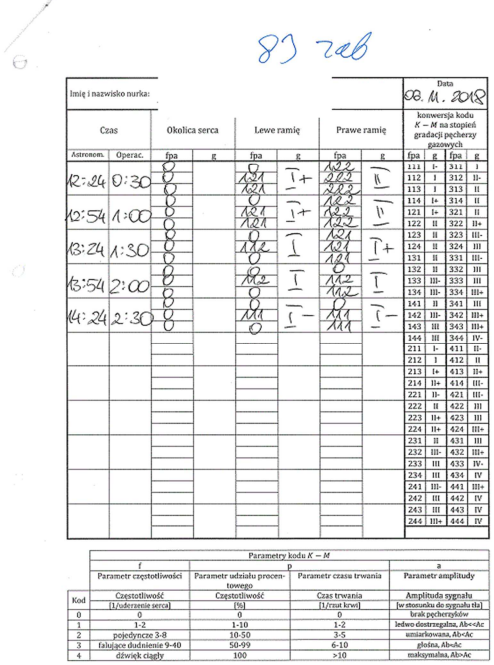
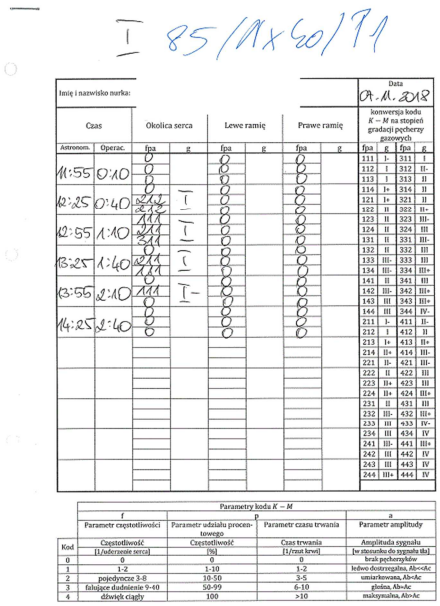


Fig. 2 Scan of Doppler screening protocol for experimental (a) and safety diver (b) – #1.

(a)



(b)

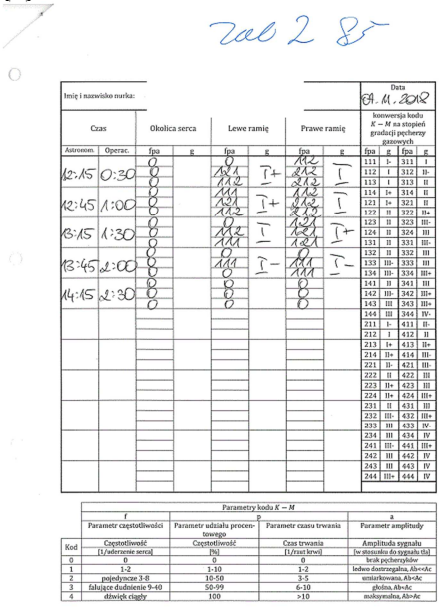


Fig. 3 Scan of Doppler screening protocol for experimental (a) and safety diver (b) – #2.

It is interesting that only during the tests on the Nx 40 %O_2 mixture the earlier announced, interesting observations concerning safety divers occurred - which is easy to notice when comparing the protocols from the experimental (a) and asecuration (b) dives in Fig. 2 and 3. After the problem analysis, we came to the conclusion that the occurrence of registrable free gas phase in venous vessels of safety divers resulted from the specificity of hyperbaric exposures, in terms of time, depth and breathing mix (air) used and concerned only the "second" safety divers - performing air exposure at the depth 40+ mH_2O, with a short stay on plateau but also with short oxygen decompression (according to *Table 3 MW*), allowing them to be "fitted" into the experimental diver's decompression profile.

In a word, therefore, these were dives "on the decompression edge", which - for obvious reasons - should be avoided... at least during real dives (especially in the implementation of underwater works), as is taught to the trainees during diving training. Unfortunately, many divers do not see such behaviour as a significant threat, often implementing decompression "on the edge", and even putting into practice various ideas concerning the diving profile, such as the idea of the "golden 50" known to older generation of divers…

What is worse, in my opinion, is that the problem of an increased risk of DCS in connection with diving "to the decompression limits" is not only related to medium and large depths: there are known cases of decompression sickness after long-term, nonetheless still allowed exposure times in the decompression table used by the diver, dives at small depths of approximately 10-12 mH_2O. We presented such a case in *PHR* publication several years ago [3].

The observations described above interested our team to such an extent that we decided to look at the recorded results of our research in other contexts. In relation to the problem of diving safety, on the basis of Doppler screening protocols of divers, we can draw a thesis that an important risk factor of a decompression incident (or even DCS) is another equally well-known variable, yet one that is rarely realized by divers - namely the time interval between the dives. And while the vast majority of divers are aware of the importance of the "in plus" break time, as in the case of a surface break between dives, or the need to use breaks during the dive cycle (a long-lasting dive operation), the problem of a break "in minus" time does not lie in common awareness - and it turns out that in the case of dives (especially those "burdensome") to medium and large depths, it is not desirable that the interval between successive dives for similar plateau is too extended.

It is my hope that in the heads of the Readers the question arises at this point: how long...? Well, for obvious reasons I will not give a precise answer - but from the observations of our team, made in relation to the group of experimental divers, constantly kept on standby, it appears that the time interval of 3-4 weeks between similar dives to medium and large depths is a factor resulting in a noticeable "deterioration" of the records in Doppler screening protocols... Simply put: wherever in a diver maintained in a diving cycle, the protocol contained "zeros" or the signal gradation was at a very low level, after too long a break (e.g. due to holidays or other work-related reasons) the scores were noticeably higher. At the same time, the application of the training procedure, consisting in gradual adaptation of the diver to the depth, definitely solved the problem - and this procedure was obligatory for all divers in connection with longer (over 1 month) breaks in the project implementation. Thus, it seems purposeful to remember that the fact that in the last season the diver (after proper preparation) performed a safe dive to the depth of 40+ mH_2O, does not authorise him/her to repeat this stunt "offhand" in the current season...

I am aware that not all of our distinguished Readers will be fully satisfied with the observations described here - as it may be reasonable to assume that this may be the "fault" of the air *Table 3 MW* utilised by us (although it has been very effectively used by the Polish Navy in the last 40 years), or perhaps of the "subjective" Doppler screening procedure based on accoustic sensitivity of my ears that become older with each passing day, or perhaps anthropometric derivatives (or some other) in the group of divers participating in the project, or, finally, the impact of some other factors...? Nevertheless, one can hardly disagree with the statement that both issues raised here, although in principle they fall into the category of "obvious" phenomena for both professionals and regular diving enthusiasts who completed the basic course of diving medicine, are rarely realized, and even less often perceived as an important risk factor of possible adverse consequences for the health and life of a diver...

…and in connection with the New Year 2019, I would like to wish the esteemed Readers (and myself) so many ascents (in full health !) as descents.

I wish to thank the Project Manager - Ryszard Kłos, Ph.D., professor at the Naval Academy of Gdynia and the Colleagues from the team organising the exposures - Arkadiusz Woźniak, Ph.D. and Roman Szymański, M.Sc., for their inspiration, help and cooperation in research.

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