SYSTEM DIVES WITH GAS MIXTURES BASED ON HELIUM

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Rezumat. *Heliul, fiind foarte inert din punct de vedere biochimic și având o densitate de șapte ori mai mică decât cea a azotului, permite performanțe superioare eliminând efectele narcozei și dificultăților de respirație. Prin punerea la punct a tabelelor de decompresie special adaptate la acest nou amestec respirator HELIOX (heliu-oxigen), limitele de adâncime impuse de aer au fost considerabil depășite și scafandrii au avut posibilitatea de a ajunge la adâncimea de 150 m.*

Abstract. *Helium, being very inert from a biochemical point of view and having a density seven times lower than that of nitrogen, allows for superior performance by eliminating the effects of narcosis and breathing difficulties. By developing decompression tables specially adapted to this new HELIOX (helium-oxygen) breathing mixture, the depth limits imposed by air have been considerably exceeded and divers have been able to reach depths of 150 m.*

Keywords: commercial diving, saturation diving, saturation systems, breathing mixture

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1 USE OF HELIUM IN DEEP-SEA DIVING

In the 1930s, the US Navy conducted experiments on supplying divers with synthetic breathing gas in which nitrogen was replaced by another inert gas, oxygen diluent, helium. The latter, being very inert from a biochemical point of view and having a density seven times lower than that of nitrogen, allows for superior performance by eliminating the effects of narcosis and breathing difficulties.

By developing decompression tables specially adapted to this new HELIOX (helium-oxygen) breathing mixture, the depth limits imposed by air were considerably exceeded and divers were able to reach depths of 150 m. However, below a depth of 150 m, when using the HELIOX breathing mixture, divers experience dizziness, slight tremors, and clumsiness, symptoms that correspond to

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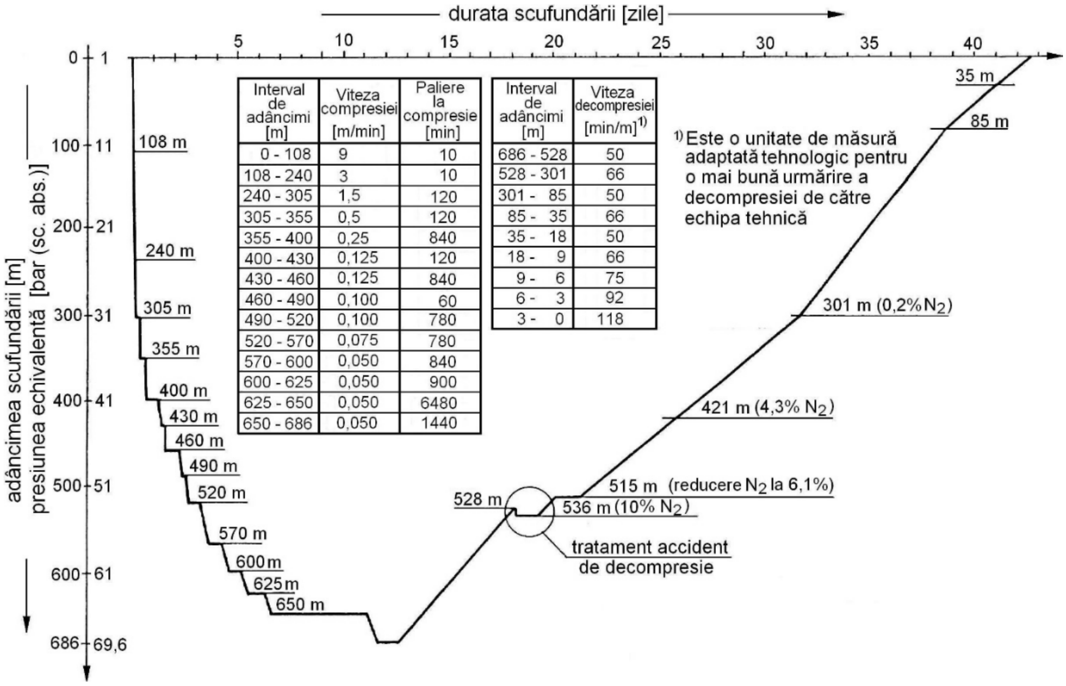
the initial phase of the central nervous system excitability syndrome described in 1968 by X. Fructus, R. Naquet, and R. Brauer under the name High Pressure Nervous Syndrome (HPNS).
In order to eliminate this obstacle, studies have been conducted since 1963 at the Hyperbaric Testing Center within COMEX, aimed at overcoming the limits of human intervention at great depths, with the aim of eliminating the effects of SNIP. By 1982, six major series of test dives had been carried out with HELIOX (helium-oxygen) or TRIMIX (helium-nitrogen-oxygen) breathing mixtures in the hyperbaric chambers of the Hyperbaric Testing Center in Marseille: Ludion, Physalie, Sagittaire, Belouga, Coraz, and Janus. Throughout this period, thanks to several hundred test dives, it was demonstrated that divers could be taken to depths of 610 m (Physalie 6, 1972, and Sagittaire 4, 1974). These test dives also showed that this could be achieved in real conditions at sea. Thus, as part of the Janus 4 program off the coast of Cavalaire, six professional divers, four from COMEX and two from the French Navy, carried out work on an underwater construction site at a depth of 460 m. On October 20, three of them, Patrick Raude, Jacques Verpeaux, and Gérard Vial, performed a dive to 500 m, a record that was not broken until 11 years later, in 1988, as part of the Comex-Hydra 8 program.
Today, several international underwater work companies routinely perform HELIOX (helium-oxygen) saturation dives at depths of 150-200 m, but there are two factors that limit the diver's effectiveness: SNIP and ventilation limitations due to the density of the gas mixture.

2. EXAMPLES OF SATURATION DIVING WITH HELIUM-BASED MIXTURES

Below are some examples of diving performances achieved with HELIOX breathing mixtures by some diving schools. Figure 1 shows the profile of the ATLANTIS III dive, carried out by American specialists at a depth of 688 m at F. G. Hall Laboratory at Duke University Medical Center (Fig. 2), Figure 3 shows the profile of the SAGITTAIRE IV dive, carried out by the French at a depth of 610 m at the Centre d'Essais Hyperbares (CEH) COMEX in Marseille (Fig. 4), and in figure 5, the profile of the PONTUS IV dive, carried out at a depth of 500 m at Hyperbaric Laboratory of the Constanţa Diving Center (fig. 6). Figure 7 shows the team of divers during a saturation dive with HELIOX carried out at the Hyperbaric Laboratory of the Constanţa Diving Center.

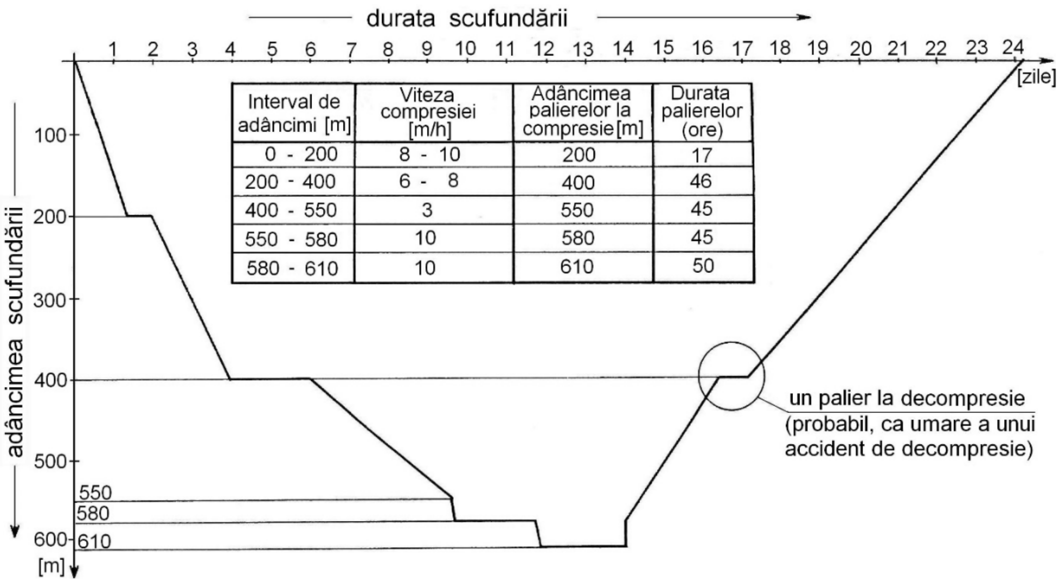


Interval de adâncimi [m]	Viteza compresiei [m/min]	Paliere la compresie [min]
0 - 108	9	10
108 - 240	3	10
240 - 305	1,5	120
305 - 355	0,5	120
355 - 400	0,25	840
400 - 430	0,125	120
430 - 460	0,125	840
460 - 490	0,100	60
490 - 520	0,100	780
520 - 570	0,075	780
570 - 600	0,050	840
600 - 625	0,050	900
625 - 650	0,050	6480
650 - 686	0,050	1440

Interval de adâncimi [m]	Viteza decompresiei [min/m][1)]
686 - 528	50
528 - 301	66
301 - 85	50
85 - 35	66
35 - 18	50
18 - 9	66
9 - 6	75
6 - 3	92
3 - 0	118

Fig. 1. Profile of the ATLANTIS III saturation dive performed at F.G Hall Laboratory, Duke University Medical Center.

Fig. 2. American divers during an experiment in the ATLANTIS III program, in the hyperbaric chamber at F. G. Hall Laboratory at Duke University Medical Center.



Interval de adâncimi [m]	Viteza compresiei [m/h]	Adâncimea palierelor la compresie [m]	Durata palierelor (ore)
0 - 200	8 - 10	200	17
200 - 400	6 - 8	400	46
400 - 550	3	550	45
550 - 580	10	580	45
580 - 610	10	610	50

Fig. 3. Approximate profile of the SAGITTAIRE IV saturation dive performed at the COMEX Hyperbaric Test Center (CEH) in Marseille.

Fig. 4 Hyperbaric chamber used for HELIOX diving, part of the hyperbaric complex at the COMEX Hyperbaric Test Center in Marseille.

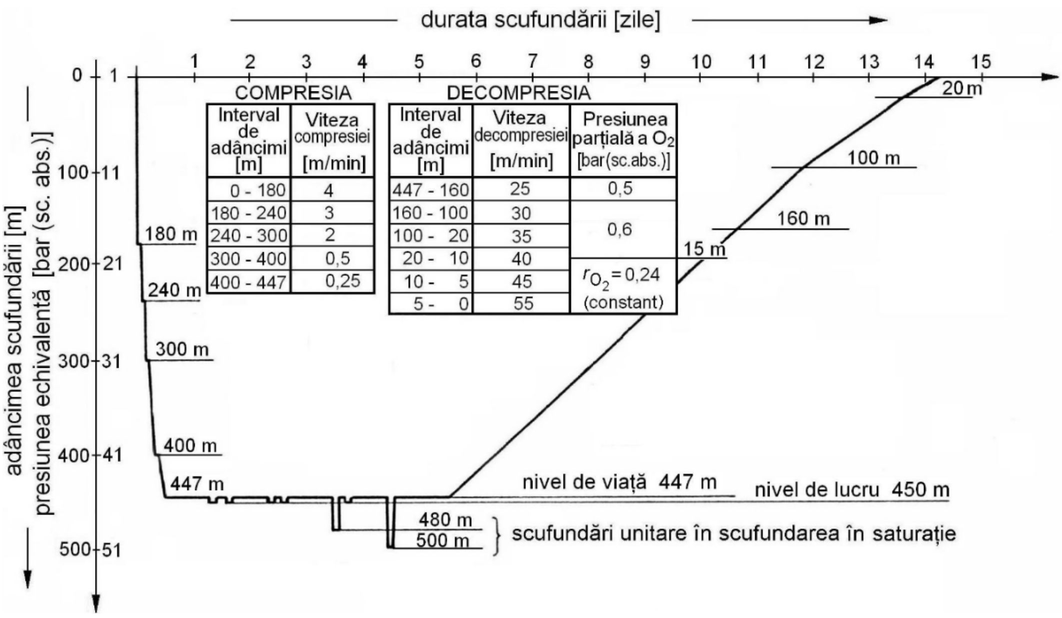


Fig. 5. Profile of the PONTUS IV saturation dive performed at the Hyperbaric Laboratory of the Constanţa Diving Center, following an original procedure.

Fig. 6. The hyperbaric system used by the Hyperbaric Laboratory at the Constanţa Diving Center.

In Romania, thanks to the efforts of the Hyperbaric Laboratory team at the Diving Center in Constanţa, a record depth of 500 m was reached in 1984 during the PONTUS IV experiment, using original technology with binary helium-oxygen breathing mixtures (HELIOX).

Fig. 7. Divers during the saturation diving program at 61 m

Pressurizing the diver with helium-oxygen mixtures induces, at depths exceeding 150–180 m, the onset of the so-called high-pressure nervous syndrome (HPNS). This syndrome manifests itself as:

• motor disorders: tremors and dysmetria, imprecision and lack of coordination of movements, loss of balance;

• decreased alertness, tendency toward disinterest, mental slowing, and drowsiness;

• electroencephalographic changes that are precarious and discrete at first, but become significant later, with the onset of slow wave patterns and bursts. These trajectories are concerning because they do not correspond to either normal sleep or anesthetic sleep.

To alleviate S.N.I.P., researches have been conducted focusing on two areas:

• reducing the compression (pressurization) rates of divers and performing accommodation stops at various depths considered critical;

• injecting nitrogen into the helium-oxygen breathing mixture in proportions of 5...20% to take advantage of its narcotic effect in alleviating S.N.I.P.

Both approaches yielded satisfactory results, allowing humans to dive to depths greater than 500 m, breathing either a synthetic binary helium-oxygen mixture (HELIOX) or a synthetic ternary helium-nitrogen-oxygen mixture (TRIMIX). Thus, in 1974, COMEX, through the SAGITTAIRE program, reached a depth of 610 m in a simulated dive using HELIOX binary mixtures, and in 1981, through the ATLANTIS III experiment conducted at the Hyperbaric Laboratory at Duke University, a depth of 686 m was reached in a simulated dive using TRIMIX ternary mixtures.

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