HYPERBARIC OXYGEN THERAPY (HBOT) AS A PRACTICE OF THE SCIENTIFIC HYPERBARIC MEDICINE AND ENGINEERING

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Rezumat. *Pornind de la ipoteza că dezvoltarea posibilităţilor de pătrundere a omului sub apă a relevat noi aspecte fiziologice şi patologice ale imersiei şi vieţii în hiperbarism, considerăm că informaţiile lucrării sunt actuale din punct de vedere al practicii medicale şi inginereşti. Pătrunderea şi staţionarea omului într-un mediu hiperbar, mai mult sau mai puţin ostil şi anormal lui, se realizează cu preţul perturbării homeostaziei, a unor modificări şi tulburări ale funcţiilor organismului acestuia care trebuie diminuate printr-o metodologie adecvată. Utilizarea terapeutică a* O_2 *hiperbar a fost abordată iniţial în Franţa şi Olanda. HBOT, efectuată la* 2÷5 bar. pres. abs.*, se află la început de drum. Tema propune realizarea unei camere hiperbare monitorizată ambiental, în măsură să îndeplinească prevederile standardului SR EN 14931 din 2006. Laboratorul Hiperbar (LH) destinat simulării scufundărilor până la adâncimea de* 500 m *(*50 bar. pres. man.*) va permite executarea tratamentelor prin HBOT pentru diferite afecţiuni. LH e realizat plecând de la o unitate standard COMEX, dezvoltată pe baza experienţei franceze în scufundări profunde, precum şi a cercetărilor la nivel mondial în materie de scafandrerie. Complexul hiperbar compatibilizat va îndeplini, cu parametri şi performanţe bune, misiunile menţionate în prezentul articol.*

Abstract. *Assuming that the great number of opportunities that facilitate underwater work revealed new physiological and pathological aspects of immersion and life in hyperbaric conditions we consider that the information contained in this paper is up-to-date in terms of medical and engineering practice. Working in hyperbaric conditions, more or less hostile and abnormal to humans, causes disruptions of the homeostasis, changes, and even perturbations in body functions, which must be reduced through proper methodology. These can and must be diminished through adequate methodology. The use of hyperbaric oxygen therapy has been approached, initially, in France and the Netherlands. HBOT, i.e. HBOT, performed at pressures of 2÷5 atm. abs. is still in its infancy. The theme supposes a monitored hyperbaric chamber able to meet the provisions of the SR EN 14931 of 2006 standard. Within the objectives pursued, the hyperbaric laboratory designated to simulate a dive to a depth of* 500 m *(*50 bar man.*) will enable treatments using HBOT for various diseases. The Hyperbaric Laboratory is based on a French standard COMEX unit experienced in deep diving and on the worldwide research results in diving. The hyperbaric complex will meet the goals we have in view within the highest standards and parameters.*

Keywords: life in hyperbaric conditions, physiology and pathology of immersion, hyperbaric oxygen therapy (HBOT), prophylactic aim and therapeutic medicine.

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1. Introduction

Hyperbaric Oxygen Therapy (HBOT), a term introduced in the medical literature in 1974 as part of hyperbaric medicine (performed at pressures of 2÷5 atm. abs.), is a method with broad clinical application, including nearly all its fields: cardiovascular pathology (congenital diseases, myocardial infarction, congestive heart failure, pulmonary oedema, cardiovascular surgery, etc.), circulatory (hemorrhagic shock, etc.) or tissue (anaemia by poisoning with CO, cyanides, nitrates, etc.), brain diseases (oedema, thrombosis, embolism), sudden central deafness, infections (especially anaerobic) oncologic diseases, removing and conservation of human organs, burns, frostbites etc. , which is still in its infancy. Underwater hyperbaric medicine (which may fall within the broad field of occupational medicine) turned into a medicine of healthy people, whose main purpose was especially prophylactic; it has turned into a real therapeutic medicine.

There are more than 2000 medical centres of hyperbaric oxygen therapy (HBO) in the world.

Within the objectives pursued, the hyperbaric laboratory designated to simulate a dive to a depth of 500 m (50 bar) will enable treatments using hyperbaric oxygen therapy for diseases related primarily to the ICU (intensive care unit): sepsis, infection with fulminatory evolution, anthrax, gas gangrene, tetanus, botulinum, hospital infections with poly resistant bacteria, actinomycoses, a aspergillosis, neuroborrelioses. These are serious infections that are fatal in the absence of hyperbaric oxygenation. Cerebral oedema, cerebral abscess, ischemic stroke, embolism, pulmonary oedema in the absence of hyperbaric oxygenation have also increased mortality whereas stroke sequelae occur in a much higher percentage (80% in the absence HBO) applies only if HBO (20%).

Another example is the otolaryngologist: acute hearing loss is treated with vasodilators 70%, the remaining 30% of the patients in the acute hearing loss can escape if they have HBO. Poliresistent ENT chronic infections are also an indication of hyperbaric oxygenation addressable favourite.

The Hyperbaric Centre Laboratory is conducted based on a standard unit COMEX developed based on the French experience in deep diving and research worldwide in diving.

2. The System Analysis

The cooperation programme in Science and Technology (COST) is a European initiative, with the objective to implement and improve cooperation between European research teams in the fields of science and technology.

The action was launched in 1998 - especially dedicated to hyperbaric oxygen therapy (COST Action B14). Participants from nineteen European countries participated in the event, be they EU members or associates of the EU.

The hyperbaric oxygen medicine, as part of hyperbaric medicine, is a method with broad clinical applicability, approaching almost all its areas: cardiovascular, circulatory or tissue pathology, brain damage, central deafness appeared in a sudden way, infections, oncologic diseases, sampling and storage of organs, burns, frostbite, etc.

The main objectives of COST B 14 were: expanding the basic knowledge for the rational use of HBO, further guidance on the development of clinical centres using HBO, and advanced research to advise on HBO in the treatment of various diseases, etc.

The Undersea Medical Society, UMS, later UHMS, Undersea and Hyperbaric Medical Society, founded in 1967, were the first companies that have set up a Committee to treat with hyperbaric oxygen, having in view the identification and classification of different clinical recommendations based on scientific evidence. The first Report of the Committee was published in 1977.

The European Committee for Hyperbaric Medicine is an organisation promoting hyperbaric and underwater medicine Europe-wide. In February 1989 in Milan, a committee with the aim of improving the quality of hyperbaric medicine in Italy was founded. The next step was a first informal meeting of the founders in November the same year at Lille. The first meeting with representatives from all European countries was held in August 1990, in Amsterdam. One of its main activities is the organization (in the European consensus) of conferences and workshops.

The objectives of the founding Committee of ECHM, defined in Milano, in 1991 were:

- Studies to define hyperbaric therapy and also indications for its use;
- Research and treatment protocols;
- Creating new common therapeutic standards, new therapeutic techniques, equipment and personnel;
- Cost-benefit criteria;

All these involved representatives of the European Community (EC) in Brussels (Belgium).

The first European Consensus on Hyperbaric Medicine was held in Lille, France, in September 1994.

Hyperbaric medicine has grown extensively covering over the years more than 60 therapeutic indications. In the period 1980-1994 the use of HBO was

questioned, but the next ten years (1994-2004) represented a fruitful scientific period in this area. The first real scientific therapeutic approach in the field of heart surgery and for the treatment of gas gangrene was made in France, and the Netherlands. An important contribution is the treatment by HBO studies research centres in Dutch schools on soft tissue infections or necrotic. In France, Toulon Naval Medical Institute was the first company to introduce HBO. Britain and the US were also among the pioneers of the application of HBO. Researchers in these countries have helped to establish procedures for HBO indications for various diseases.

The indications for HBO were agreed upon at the ECHM Consensus Conference in Lille, in September 1994, and updated 10 years later, also in Lille, in December 2004. In order to be considered acceptable, any indication had to be based on experiments and clinical trials conducted with strict methodology and demonstration of significant positive results.

The jury has issued recommendations using a three-tier scale of recommendations: Type 1 – recommended with demonstrated certainty, Type 2 - recommended with probable certainty, Type 3 - recommended with optional certainty. For example:

Type I:

- CO acute poisoning.
- Crushing syndrome.
- Prevention of osteoradionecrose after dental extraction.
- Osteoarthritis of mandible.
- Radionuclide soft tissue therapy.
- Accidents of decompression.
- Gastrointestinal embolism.
- Anaerobic or mixed bacterial infections.

Type II:

- Diabetic foot.
- Compromised skin or musculocutaneous graft.
- Osteoarthritis (other bones).
- Radio-induced proctita / enteritis.
- Radio-induced lesions of soft tissues.
- Irradiated tissues after surgical implant (prophylactic).
- Sudden Deafness.
- Ischemic ulcer.
- Chronic refractory osteomyelitis.
- Neuroblast Stage IV

Type III:

- Post-anoxic encephalopathy.

- Laryngeal radiography.
- Induced radioactive CNS damage.
- Vascular reperfusion syndrome.
- Body re-implants.
- 20% surface burns of 2nd degree.
- Ophthalmic ischemic disorders.
- Inflammatory processes associated with non-healed secondary injuries.
- Infestation with Pneumatosis cystoides intestinalis.

3. The Internal Situation

"S.C. Eurohiperbar S.R.L." - situated in the centre of Constanta - possesses one of the most modern pressure rooms in Europe, equipped with the most modern computerized monitoring systems of treatment and patients at the level of German therapy standards.

Their Hyperbaric Chamber has the option of simultaneous treatment of 13 patients and an attendant or to 4 stretchers. Each treatment site has separate oxygen supply. The Chamber has the ability to perform hyperbaric treatments up to 50 meters deep / 6 bar (absolute scale), 5 bar (relative scale). According to the European norms in force, the pressure chamber has: an access door for people with the possibility of oxygen supply to four people (for emergency access of doctors and medical staff, removal or introduction of patients during the treatment schedule), medicine and instrumentation small access door, quick decompression valve in the event of fire both in the main chamber and in the air lock (for quick discharges), power supply (UPC) for 60 minutes of activity, possibilities of storing compressed air for three large treatment schemes in the absence of electricity, fire-fighting system (300 litres of water at 50 bar) pneumatically actuated, without the need for electricity with water and fog nozzles according to the European and international standards for fire fighting under pressure (installation under German patent), computerized air conditioning system that allows compression and decompression without significant temperature changes; camera control can be done in three ways: electronic (fully automated by a computer program), electric (by a chamber man) and pneumatic (without the presence of electricity), etc. Patients' monitoring during treatment can be performed both by the physician present in the pressure chamber and in real time by specialists at the Institute of Hyperbaric Medicine and Diving in Bielefeld.

The Hyperbaric Medicine and Diving Centre in Constanta operates under the direct supervision of specialists with a rich experience in the field of hyperbaric medicine at the Institute of Hyperbaric Medicine in Bielefeld, institute that coordinates the activity of the Hyperbaric Medicine Centres in Bremen, Minden, Osnabrück, Wuppertal and Rammstein (within the US Military Hospital). The

Bielefeld Institute and its physicians are members of the German Association of Hyperbaric Medicine and Diving (GTÜM) affiliated to ECHM (the European Committee of Hyperbaric Medicine), which is in coordination with UHMS (Undersea & Hyperbaric Medical Society), JSHUM (Japanese Society of Hyperbaric and Undersea Medicine). GTÜM together with ACHOBEL (Advisory Committee for Hyperbaric Oxygen in Belgium), BHA (British Hyperbaric Association), MEDSUBHYP (Société de Médicine et de Physiologie Subaquatiques et Hyperbares de Langue Française), ÖGTH in Austria and SUHMS in Switzerland centralizes the results of European studies and decides the ECHM norms.

The present configuration of the Diving Centre's ASS 500 Hyperbaric Complex, which covers the range of missions listed in another chapter, namely treatment of those involved in diving accidents, carrying out oxygen and narcosis tests, training the divers in a dry and wet environment, previously regarding unitary and saturation diving activities, comprises: a central hall, a compressor compartment, regeneration assembly and gas storage, a compartment for various groups of power and water supply.

Fig. 1. The Diving Centre Hyperbaric Laboratory.

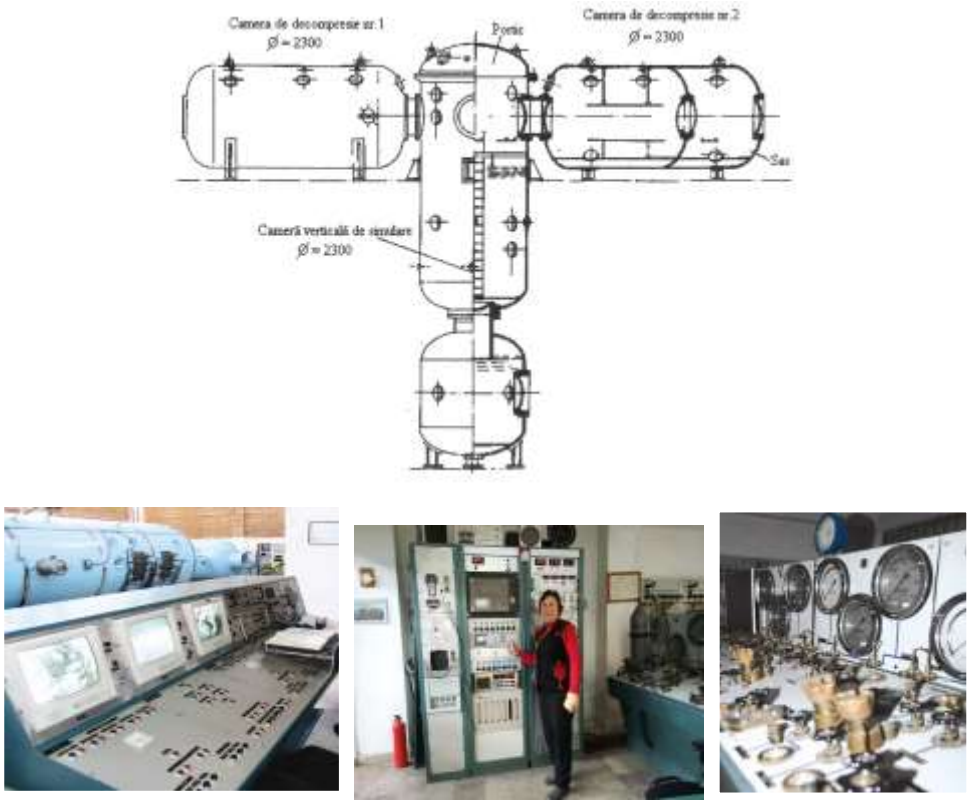

Fig. 2. Monitor for Gas Monitoring and Management (the control panel).

4. Case Study - Identified Shortcomings

The standard has general constructive and functional characteristics of the pressure chambers and it details the necessary endowments and the technical constraints in case of therapeutic use.

In the presentation of the non-conformities a numbering system was used with subchapters SR EN 14931: 2006, to be easily identified to completion.

- (4.2.19) the materials inside must be antistatic according to EN ISO 6941 or similar;
- (4.2.19) the materials inside must be hardly combustible according to EN ISO 6941 or similar (paint, upholstery. etc.);
- (4.2.19) each compartment must be equipped with fire extinguishing materials (ISO standard was developed after the adoption of this) or a special extinguishers pressure chamber;
- (4.2.19) the existence on the outside of the pressure chamber of a breathable sources of air;
- (4.2.17) control manometer of the inside pressure with 1% precision on the entire measuring scale, calibrated;

- Posting the no flammable or non-approved materials signs in visible spots;
- (4.2.13) an independent emergency illumination system from the main system with a illumination capacity of min. 90 lx;
- (4.2.21) according to the standard, the inside electrical installation cannot go over 42 V, fitted with a safety system;
- (4.3.2) the existence of a calibrated safety decompression system allowing decompression of 2 bar. to Ambient in max. 2 min.;
- (4.6.1) compressed air purity according to EN 12021 or STANAG 1458. The existence of ballots analysis. Filtration;
- (4.3.8) conditioning system inside the hyperbaric atmosphere;
- (4.5.3) monitoring and analysis data storage system with the possibility of analysing at least the last 3 hours;
- (4.5.5) visual and audible alarm system for when the O_2 concentration is exceeded inside the pressure chamber;
- (4.5.6) at least two timers;
- (4.9.2) additional power supply, source type UPS monitoring equipment.

Annex B presents the devices and dedicated medical equipment used in the hyperbaric environment by types of interventions.

As presented above, cutting-edge achievements do not reflect changes regarding the basic principles or structure. Built on a different scale, the systems retained the same functional framework.
The differences imposed by the new objectives and missions refer to the following aspects:

- air-conditioning the hyperbaric environment throughout the diving process within the “System” (compression-level-decompression);
- the existence of a centralized data acquisition system. This is done either classically by using a process computer responsible for data acquisition and recording, or with smart programmable and intelligent controllers (as FieldPoint ones) owning implemented personalized soft applications for the process for which they were designed. Regardless of the solution adopted for the acquisition;
- import of the complete set of parametric data from each pressurized compartment (pressure, humidity, CO_2, O_2, temperature). The transducers responsible for capturing the above mentioned parameters are present for each depth range so that the “full scale” reading errors to be as minor as possible;
- oral-nasal and spill-off masks made of high-toxicity nontoxic materials;
- process analyzers for oxygen, high precision and response rate (by the free-electron paramagnetism method);
- CO_2 process analyzers (usually infrared);

- video monitoring and recording for each pressurized compartment.

4.1. Proposals on the implementation options

Analyzing the data presented above, there is the need for optimizing environmental factors by monitoring and adjusting the essential parameters of the breathable atmosphere during the activities held in the Chambers. This would be *the first step* towards the compatibility of the system. The following steps can be performed as follows:

Second stage Air conditioning during activities;

As regards the first stage, the constructive versions must respond to the following identified needs in order to optimize the environmental factors by monitoring and adjusting the essential parameters of the breathable atmosphere during the activities held in the Chambers:

1. Completing and strengthening the transducer system for all relevant physical sizes within the diving process (pressure, humidity, pp_{CO2}, pp_{O2}, temperature);
2. Achieving the purchasing system for these parameters;
3. Ensuring inertia trails between transducers and the data acquisition system;
4. Implementing own software applications based on a specific development environment such as the Lab VIEW Full Development System Ver. 8.0. These applications handle the following:

- Parameters monitoring and recording in real time;
- Data interpretation according to the type of diving algorithm implemented in the software;
- The ordered parameter adjustment of the software based on the existent comparative values in the database;
- Process controls for automatic adjustment.

4.2. Description of possible versions to be carried out, indicating advantages and disadvantages

Basically, two options have been identified to achieve the proposed objective in the first stage:

First version

A. Measuring the immersion depth in the Chambers

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	High pressure precision transducer 0 - 35m	0 – 50 psi; precision: ±0.1%; code P-68971-08	Replaces the current defective DRUCK transducers
2.	High pressure precision transducer 0–700m	0 –1000 psi; precision; ±0.1%; code: P-68971-18	Replaces the current defective DRUCK transducers

3.	Digital display	Precision: ±0.5%; 4 ½ digits; Code: P-94709-40	Replaces the COMEX display, technically outdated

B. Measuring the temperature in the Chambers

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	Ambient temperature transducer	Platinum Thermoresistance -50°C ÷500°C; Code: P-08117-90	Replaces faulty current transducers
2.	Digital temperature display	Precision : 0.7°C; Code: P-93279-25	Replaces the COMEX display, technically outdated

C. Measuring the CO_2 concentration

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	CO_2 analyzer	0 – 0.5% (5000 ppm) Precision: ±1%; Ref. 1000 0902	Replaces the current SCHLUMBERGER analyzer, technically outdated

D. Measurement of partial oxygen pressure in the Chambers (PPO_2)

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	Oxygen analyzer with partial pressure display (O_2 Analyzer PPO_2)	Electrochemical transducer; Domain: 0 – 2 bars; Precision : 1%; Display 4½ digits; Code:1000 4199	It replaces the current COMEX system, technically outdated and defective because of the lack of transducers
2.	PPO_2 Display	4½ digits; Code: 1000 1227	It replaces the current COMEX system, technically outdated and defective because of the lack of transducers
3.	Hyperbaric oxygen transducer	Electrochemical type; Code: 1000 4169	Missing in the plant

E. Closed circuit television

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	Colour camera	Min. luminosity 100 lx Power 20Vcc; A wide-angle lens f: 1,716; colour	Fill in the surveillance capabilities for each pressurized compartment
3.	Colour monitor	Power: 220V;	Items which are to be completed
4.	Audio-video recording system	Power: 220V, Input: Microphone, tuner, cassette recorder	Replaces the current defective system

F. Measurement of oxygen concentration in the Chambers

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	Industrial oxygen analyzer, SERVOMEX type	Type N Code: 00540A7 –06-03-0-1-0-1-0-0-0-0-0-0-0-0 Scale: 0-1; 0-2,5; 0-5; 0-10; 0-25; 0-50; 0-100%	To duplicate the current measurement system, given the importance of accurate and non-discontinuous measurement of O_2 concentration

		Power: 220/50Hz; Accessories: Direct output card. Part No. 00540 904.	during the diving processes and especially in saturation decompression.

G. Data Acquisition and Processing System (Diving Parameters Record replaces the current technically outdated LINSEIS system)

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	backplane cFP-BP-4	4 slots	Where up to 4 cFP modules can be mounted; there is also a version with 8 slots
2.	Controller Intelligent, cFP – 2200		It is the minimum version, there are other modules but more expensive
3.	cFP-AI-110	module with 8 analogue inputs in current or voltage	
4.	Industrial food source, PS-15	24V 3-5A	There is also the possibility of purchasing cheaper sources from another manufacturer
5.	cFP-DI-330	8 digital inputs, 24V c.c.	For noticing phases in the process (logical phases related to closure / opening of valves, pumps, thresholds, etc.)
6.	cFP-RTD-122 or cFP-TC- 120	8 inputs from thermosensors or thermocouples	
7.	cFT-RLY- 421	8 SPST relay channels	For possible commands in the process
8.	cFP-CB-1	connector block	For each used module one connector block (cFP-CB-1 type) must be purchased through which the connections to / from the sensors are made
9.	SH37F-YP	Connectors / circuit closers	A more economical version for the connector block: by using instead of cFP-CB-1 connectors one end-to-end connector cable that is attached to the backplane and the other end is free, being able to be connected directly to sensors
10.	Soft application	Software Compact FieldPoint and Lab VIEW Full Development System Ver. 8.0 drivers	

Second version (different from the former version is the fact that it only refers to Data Acquisition and Processing System)

G. Data acquisition and processing system

No.	*Device name*	*Type, domain, precision*	*Observations*
1.	C-Series USB Single Module Carrier, USB-9162 model	USB Single Module Carrier	Connects the PC to the data acquisition module. Inside it, one can install different C-Ceries data acquisition modules according to the needs or types of signals to be measured)
2.	C-Series Data Acquisition Module, NI-9201 model	8 analogue channels +/- 10V, galvanic isolation, sampling rate: 500kS/s, resolution 12 bit	It is installed in the carrier module
3.	NI-DAQ software Driver in the NI-Signal Express version	8 digital inputs, 24V c.c.	A very easy software package with which one can set up a measurement application
4.	NI-9472 module	8-channel digital output module, 6-30 VDC	It can be used for commands in the process
5.	NI CompactDAQ 4-slot chassis, cDAQ-9174 model	4-slot backplane	It can include up to four data acquisition modules in it
6.	Soft Application	LabVIEW Full Development Sys.Ver.8.0	

5. System/Cost Efficiency Analysis. Comparison of Possible Solutions, Conclusions on Their Efficiency and Economy.

From the analysis carried out on the above-mentioned types of versions, it was established that the principle of efficiency and the technical-economic principle are optimized by using the 2nd version.

6. Conclusions, Proposals

The ASS 500 Diving Centre hyperbaric assembly is technically and constructively compliant with the SR EN 14931: 2006 (annex 2) standard which accounts for 90% of the endowment conditions necessary for its use according to the designation, for which it was intended, in a safe mode. Major non-conformities identified, and proposed solutions:

a) – the lack of an automatic fire extinguishing system or fire extinguishing means intended to the use in hyperbaric environment. (The standard allows for the

use of intended fire extinguishers located inside Chambers. According to the Chamber's Technical Manual, the paint used is fireproof. According to the chamber operating methodology, it is forbidden to enter with flammable items and the staff's clothing must be of natural fibres which do not allow electrostatic charging. Electric motors in the interior are designed not to produce sparks during operation);

b) – the lack of a data storage system. At the moment, measurements and important data in the process can be recorded on technology sheets;

c) – the lack of an air source for breathing in a toxic environment, outside the Chamber (a breathing apparatus may be used in a toxic environment, identical to that provided by the AOSP);

d) – the lack of sound and visual warning devices for O_2 and CO_2 analyzers when the threshold values are exceeded;

e) – the lack of compressed air analysis bulletins (there is a technical study for the performance of a gas analysis laboratory which is partly equipped);

f) – additional own power supply system (lack of LH equipment accumulators, the emergency power system is inoperable). Purchasing an independent lighting system of the Chamber independent of the main system;

g) – medical devices that can be applied when using the Hyperbaric Chamber for therapeutic purposes must withstand at least the stresses generated by a pressure of 2 bar.

Visible display of signs which ban access with flammable or non-approved materials.

In the context of the current use, the medical equipment involved in the process responds to the needs for which the Hyperbaric Chamber was designed (aptitude test, treatment of diving accidents, simulated diving and saturation), consisting of a first aid kit and also medicines in accordance with the "red card" (red manual).

The current configuration of the Hyperbaric Chamber, its utilization methodology and that of its installations, as well as the operational procedures regarding the process of divers testing and training allow the safe use of the ASS 500 Hyperbaric Chamber.

In order to maintain a high degree of operability, it will be insisted on the training of service technicians (since most of the actuations are manual), periodic simulation of emergency situations, observance of the maintenance plan and maintenance of service installations and equipment.

Considering the fact that the Diving Centre, through the Hyperbaric Laboratory (LH), broadly owns the necessary infrastructure for putting this kind of therapy into practice, it clearly shows its potential to become one of the Hyperbaric Oxygen Therapy-specific areal entities.

Analyzing the current technical level regarding the system's performance and taking into account the international trends, one can notice the opportunity to be compatible with minimum investments due to the favourable situation created by the already existing infrastructure within the hyperbaric laboratory, as well as to the evolution of the line equipment.

By way of example, a hyperbaric complex remained structurally identical and the superior technical requirements and visions (progress) mainly metamorphosed the part related to sensors, automation and data acquisition.

Thus, in order to consolidate the old performances and in addition to align them with the current requirements and technologies of hyperbaric oxygen therapy, the idea of modernization revolves around "common sense" interventions.

Fig. 3. Types of Hyper-tech multi-lock chambers.

Figure 2. Various versions of mono and multi-lock chambers for oxygen therapy.

7. Staff Training

The doctors' specialty training

- Curricula are developed for different staff categories for hyperbaric activities and competency levels by profession.

- Specialised education is based on a modular system, with mutual recognition of core standards throughout Europe, and calibration through a credit system based on the minimum length of required training, focusing on basic elements.

The documentation to be presented in the theoretical hours is necessary in order to be able to use the obtained information both in the laboratory research and in the hyperbaric practices; it also provides material support for obtaining the level II and III in hyperbaric therapeutics under the authority of the European Committee for Hyperbaric Medicine (ECHM). The present study elaborated by the Centre's specialists presents also the theoretical training module for the specialised technical and medical personnel.

Strict specialised terms:

Single (or, better, *simple* – i.e. *without nothing*) diving = successive execution of the following operations: effective compression in immersion and decompression, it can be of two kinds: autonomous and systemic,
Diving in saturation = long-time sinking where the exposure of divers is made to an ambient pressure, corresponding to the depth of immersion, long enough for the body tissues to saturate with the gas or inert gases of the respiratory mixture composition.

Acronyms and Abbreviations

ACHOBEL = Advisory Committee for Hyperbaric Oxygen in Belgium,
AOSP = the help of the officer on duty at the control point,
ASRO = the Romanian Standards Association,
ASS 500 = ensemble for unitary simulated and in saturation diving process that runs up to a maximum depth of 500 meters,
BHA = British Hyperbaric Association,
COST = The Science and Technology Cooperation Program is a European initiative program with the objective of applying and improving cooperation between European research teams in the fields of science and technology.
EBM Criteria = Evidence-Based Medicine
ECHM = the Medical European Commission for Hyperbaric Medicine,
ECGP = European Code of Good Practice for Hyperbaric Oxygen Therapy,
GTÜM = German Association of Hyperbaric Medicine and Affiliated Scuba Diving ECHM,

HBOT = Hyperbaric oxygen therapy,
JSHUM = Japanese Society of Hyperbaric and Undersea Medicine,
LH = Hyperbaric Laboratory,
MApN = Ministry of National Defence,
MEDSUBHYP = Société de Médicine et de Physiologie Subaquatiques et Hyperbares de Langue Française,
ÖGTH = Austrian Association of Hyperbaric Medicine and Diving,
pp = partial pressure ($ppCO_2$, ppO_2),
R & D = research and development,
SUHMS = Swiss Association of Hyperbaric Medicine and Diving
SCAS = Department of Research and Development of Diving Activities,
UMS = Undersea Medical Society,
UHMS = Undersea and Hyperbaric Medical Society, established in 1967.

R E F E R E N C E S

[1] *Directives 1000.1, 1000.2, 1000.5* of the Armaments Department of the Ministry of Defense.

[2] STP-M 40369-98: *Quality assurance. Terms and definitions*.

[3] STP-M 40361-98: *Technical requirements for the design and implementation of the quality assurance program by the contractor*. Guide.

[4] STP-M 40462-98: *Military requirements for a quality assurance system in design, development, production, assembly and service*.

[5] STP-M 40463-98: *Military requirements for a quality assurance system*. Guide for application of STP-M 40462, STP-M 40464 and STP-M 40465.

[6] STP-M 40464-98: *Military requirements for a quality assurance system in production, assembly and service*.

[7] STP-M 40465-1998: *Military requirements for a quality assurance system in final inspections & tests*.

[8] STP-M 40466-98: *Military requirements for a quality assurance system in final inspections*.

[9] STP-M 40469-98: *Product Quality Assurance Program for Military.* Guide.

[10] SR EN 14931:**2006** *Chambers for human use. Chambers with multiple seats for therapeutic use. Performance, security requirements and attempts*.