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## **NEW POLISH OCCUPATIONAL HEALTH AND SAFETY REGULATIONS FOR UNDERWATER WORKS**

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### **ABSTRACT**

In Poland, the new regulation of the Ministry of Health on Occupational Health for Underwater Works (dated 2007) pursuant to the Act on Underwater Works (dated 2003) has just been published. It is dedicated for commercial, non-military purposes. It defines health requirements for commercial divers and candidates for divers, medical assessment guide with a list of specific medical tests done on initial and periodical medical examination in order for a diver or a candidate for diver to be recognised fit for work, health surveillance during diving operations, compression and decompression procedures, list of content for medical equipment to be present at any diving place, formal qualifications for physicians conducting medical assessment of divers, requirements for certifications confirming the medical status of divers and candidates for divers. Decompression tables cover divers up to 120 meters of depth using compressed air, oxygen, nitrox and heliox as breathing mixtures. There are also decompression tables for repetitive diving, altitude diving and diving in the high-density

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waters (mud diving). In this paper, general description of health requirements for divers, as well as decompression tables that are included in the new Regulation on Occupational Health for Underwater Works are presented.

#### KEYWORDS

regulations, commercial divers, underwater works, breathing mixture, decompression table

### INTRODUCTION

Currently there are tens of civilian companies conducting underwater operations in Poland. The number of professional divers is estimated to be about two thousands, not counting military divers. Previous national regulations concerning health and safety for commercial divers were introduced in Poland in 1965 by the Act on Underwater Works (1). Those regulations were covering only dives conducted using compressed air up to 60 meters of depth while using hard hat systems. In the text of those regulations, there was a paragraph stating that detailed medical assessment standards with decompression tables will be published soon. This was true for the medical assessment standards which were published in 1971 (2), however regulations with decompression tables have never been introduced. This led to situation where every diving company, including those national ones, could choose without control any decompression table from several systems which were officially known in this region of Europe (for example, decompression tables of the Polish Navy, US Navy or Russian Navy). In that time, there was no significant number of diving accidents observed during commercial operations. However, on the other hand, there was no national program for health assessment for commercial divers nor national register for diving related health problems and this precludes acceptance of such situation as safe for the future.

Since many years, there were trials in Poland toward changing the national regulations in order to make them more compatible with modern way of underwater operations, which should include different types of diving equipment and different breathing mixtures (at least oxygen, nitrox and heliox). Because in this field of interest, there is no internationally approved law act in the European Union, introduction of national regulations was done on the local level of Poland using experience and knowledge of different countries.

In this paper we present a new Polish occupational health and safety regulations for commercial divers in the part which concerns health assessment and decompression tables.

The new regulation has been introduced in Poland in 2003 as the Act on Underwater Works (3). This Act has been covering all underwater operations with exception of dives conducted for military, sport and recreational purposes. Based on this Act, the Polish Ministry of Health prepared the Regulation on Occupational Health for Underwater Works (4) conducted under the scope of the Act. This Regulation defines:

- health requirements for commercial divers and candidates for divers,
- medical assessment guide with a list of specific medical tests done on initial and periodic medical examination in order for a diver or a candidate for diver to be recognised fit for work,
- health surveillance during diving operations,
- compression and decompression procedures,
- list of content for medical equipment to be present at any diving place,
- formal qualifications for physicians conducting medical assessment of divers,
- requirements for certifications confirming the medical status of divers and candidates for divers.

The Regulation defines that any person who has not have any contraindication for commercial diving is recognised as fit for underwater work. The medical assessment must be conducted by physician who: 1) is specialised in the maritime and tropical medicine, transport medicine, occupational medicine or aerospace medicine and 2) who has participated in the training course conducted in the centre for hyperbaric medicine working on the academic level as a part of the medical university. In the Regulation there are general guidelines for medical assessment which enlists several medical contraindications for underwater works. This list is not exhaustive and it includes all conditions and diseases which: 1) limit the ability to perform the job as a diver, or which 2) jeopardize the safety of a diver and predispose the diver to diving or occupational illness, or which 3) might deteriorate as a result of underwater work. Basic tests for the respiratory system evaluation are plain chest x-ray and spirometry. The results of the spirometry should give sufficient evidence for normal lung function, which is confirmed if all results are at the level of at least 80% of reference values (70% for the Tiffeneau-index [FEV1%IVC]). Basic tests for the cardiovascular system evaluation are rest electrocardiogram, exercise stress test and maximal oxygen consumption during the submaximal exercise (which should be lower than 40 ml/kg/min).

The initial (pre-entry) medical examination for candidates for professional divers includes:

- general medical evaluation;
- plain chest x-ray;
- functional tests of the respiratory system (spirometry and maximal oxygen

consumption);

- 12-lead rest electrocardiogram (with exercise stress test for persons older than 45 years);
- otolaryngological examination with audiometry;
- EEG activity during active hyperventilation and visual stimulation;
- blood morphology and biochemistry parameters (glucose, urea, creatinine, cholesterol, triglycerides, albumins);
- routine urine screening test;
- x-ray images of long bones and large joints (shoulder, hip and knee joints);
- pressure test, which confirms the ability of diver or candidate for diver to compress to at least 3 bar (0,3 MPa) with the compression rate of at least 1,2 bar (0,12 MPa/min). This test should be conducted in the multiplace chamber with physician inside the chamber;
- any additional consultations or other medical tests which are necessary for proper medical assessment.

The routine medical assessment is conducted annually, but for divers older than 40 years it is conducted every 6 months. The medical re-assessment is conducted also in every case of:

- any disease or accident which prevents diver from working underwater for longer period of time than 30 days;
- diver's request;
- request of diver's employee.

Such regular medical assessment is basically the same as an initial medical examination with the following exceptions:

- there is no need to repeat the measurement of the maximal oxygen consumption (unless specifically indicated);
- there is no need to repeat the full otolaryngological examination (unless specifically indicated), but the audiometry is repeated annually;
- there is no need to repeat the measurement of the EEG activity during active hyperventilation and visual stimulation;
- x-ray images of long bones and large joints (shoulder, hip and knee joints) are taken every 4 years, unless there are symptoms which need more frequent assessments.

The Regulation indicates that the diving company which organizes the underwater work is responsible for the organization of the medical evacuation of an injured diver to the centre for hyperbaric medicine. Such transport should be organized in cooperation with this centre using any applicable way, including air evacuation. An alternative way could be installation of hyperbaric chamber with personnel on the diving site to serve as

a medical support. The Regulation describes also qualifications of physicians which are able to supervise diving operations on site. Such physicians must be specialised in anaesthesiology and intensive care or emergency medicine. They also must finish the course on pathophysiology of diving and basics of hyperbaric medicine and take part in the training period in the centre for hyperbaric medicine.

According to the Regulation, in every case of diving accident when the injured diver needs specialised medical assistance, the diving company must inform the centre for hyperbaric medicine giving written report about the accident.

The main part of the Regulation defines the compression and decompression procedures. It is divided for compressed air/nitrox and heliox operations.

In most cases, decompression tables for compressed air and nitrox are described in 3-meter depth intervals and 10-minute time intervals. Those tables cover depth range from 12 to 60 meters of depth. According to the Act on Underwater Works, which is the document of the higher level to the Regulation, diving operations using compressed air are allowed to the depth limit of 50 meters. Therefore, decompression tables described in the Regulations for depths from 51 to 60 meters can be used only for emergency situations. According to the decompression tables, descent rate should be lower than 30 m/min and ascent rate should be kept between 9 and 15 m/min. There is a restriction for physical exercise during the ascent phase, as well as for post-diving period of time. The diving is repetitive if the surface interval is shorter than 12 hours. Oxygen can be used for decompression optimization, as there are tables for oxygen usage while on the decompression stop on 6 or 12 meters. There is also a procedure for surface decompression, which should be conducted with the maximum allowed delay of 4 minutes between leave of depth of 9 meters of in-water decompression stop to the recompression to pressure of 1,2 bar (equivalent of depth of 12 meters) in the decompression chamber.

In the Regulation, several emergency procedures are described in more details, namely: 1) bottom time in excess of the plan, 2) unsafe diving conditions, 3) surface interval in excess of the allowed limit before in-chamber decompression and 4) loss of oxygen in the decompression chamber.

Several different planning options are described as the equivalent depths' tables. Those options include:

- altitude divers at elevations over 300 m above the sea level, up to 3000 m above the sea level (700 mbar of barometric pressure);
- multilevel divers;
- mud divers in waters with greater density, up to 1.4 of relative density.

Tables for repetitive divers describe first diving and one diving conducted within 12 hours of surface interval. Such divers are not allowed for surface decompression.

The user can use two methods described in the Regulation for planning the repetitive divers. First method uses equivalent bottom time described in the separate table. This method is preferable because decompression time is shorter. Second, alternative way uses summed time of both divers altogether with the largest depth reached during both divers (not counting the surface interval) to plan the decompression. This method is more conservative as it results with longer decompression times.

In the Regulation, there are also decompression tables for heliox divers:

- to the depth range of 30 - 50 meters with oxygen decompression on 6 meters of depth;
- to the depth range of 30 - 78 meters with oxygen decompression on 12 meters of depth;
- to the depth range of 30 - 120 meters using diving bell and transfer under pressure (TUP) to the decompression chamber.

According to the Regulation, during every heliox diving, the partial pressure of oxygen during the bottom phase is kept on the maximum level in the range of 0.85 – 1.55 bar, which is 10 – 30% as depending on depth and fractional amount of oxygen in breathing mixture. During every oxygen decompression conducted on the depth of 12 meters, diver breathes 25 minutes of oxygen with a 5 minute compressed air break.

Besides decompression systems, the Regulation describes the list of content for medical equipment which must be available at any diving place. This package includes:

- resuscitator kit;
- oxygen first aid kit with at least two oxygen cylinders for at least 1500 liters of oxygen capacity, with regulator and face mask applicable for supply an injured diver with at least 90% of oxygen;
- other medical equipment (blood-pressure measuring device, stethoscope, thermometer);
- wound dressing;
- personal protective accessories and equipment (masks, gloves);
- local disinfectants;
- wound disinfectants.

The volume of the Regulations counts 285 pages.

## DISCUSSION

New Polish regulation for commercial diving is dedicated to civilian (non-military) purposes. For the first time in Poland there is a wide spectrum of decompression tables

presented for different breathing gases including compressed air, oxygen, nitrox and heliox up to the depth of 120 meters, which covers the Polish zone of the Baltic Sea shelf. In the Regulation, there are also decompression tables for altitude diving and diving in the high-density waters (mud diving).

One of the most important positive impacts of the Regulation on the national system for diving and hyperbaric medicine, is that for the first time it introduces the term “centre for hyperbaric medicine”. At present, there is only one hyperbaric centre in Poland which fulfils the basic requirement enlisted in the Regulation which is the connection to the medical university. This is the National Center for Hyperbaric Medicine in Gdynia of the Medical University of Gdańsk. This centre has the capability to treat any case of decompression sickness or arterial gas embolism. The centre is equipped with several multiplace hyperbaric chambers, which allow the intensive care under pressure using any type of recompression treatment regime using oxygen, nitrox, heliox or trimix. There is a mobile decompression station (dual-lock multiplace chamber in self-contained container with dedicated gas storage, gas compressors and power supplies) and a transportable chamber for two persons (patient and medical attendant) which can be used for transport of the injured diver under pressure into the stationary hyperbaric medical system (TUP, transport under pressure).

Due to time and funds limitations, regardless great experience of Poland in the development of decompression tables for military purposes, the current Polish national regulations for civilian divers were based on actual decompression regulations published and used in France since 1990 (5). Usage of the French system reflects recognition of its value in the field of commercial divers by the Polish government.

Unfortunately, despite many efforts, we failed to include in those regulations two important items which would improve the safety of diving and hyperbaric operations. Firstly, the Act on Underwater Works does not cover explicitly personnel of the medical hyperbaric facilities, who are also at risk of diving-related injuries and decompression sickness. Such persons are not automatically covered by those regulations, even if their professional activity is recognized per analogiam as diving-related professional risk. Secondly, there was a project to create the national register for commercial divers, which would allow monitoring of the underwater operations and personal exposure for diving-related risks. Such registers, which are used currently in other European countries (for example in the United Kingdom), would allow precise recognition of the risks of commercial divers. Actually, according to the Polish Act and the related Regulation, there will be a register established of all diving related accidents, however the analysis of those reports will not be as complete as it was wanted to be due to lack of information about the total number of man-hours during underwater operations.

## CONCLUSIONS

New regulations on occupational health and safety for commercial divers give positive impact for further development of this type of professional activity in Poland. Those regulations allow conducting underwater operations down to 120 meters of depth while using compressed air, oxygen, nitrox and heliox and this covers all inland waters and most of the Polish part of the Baltic Sea shelf.

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