EDUCATIONAL AND TRAINING STANDARDS FOR PHYSICIANS IN DIVING AND HYPERBARIC MEDICINE

Written by
Joint Educational Subcommittee
of the European Committee for Hyperbaric Medicine (ECHM)
and the European Diving Technical Committee (EDTC)

List of content:

Foreword

These educational and training standards are the result of some years of international discussion and extensive educational experience both in diving and hyperbaric medicine. It is based on two main documents:

1. "*Educational and Training Standards for the Staff of Hyperbaric Medical Centres*" written in 1997 by Jordi Desola, representative of the European Committee for Hyperbaric Medicine (ECHM), and Jurg Wendling, representative of the European Diving Technical Committee (EDTC) for the Joint Educational Subcommittee of the ECHM and EDTC.[1]
2. "*Training Objectives for a Diving Medicine Physician based on current ECHM, EDTC and DMAC sources*" prepared by David Elliott with subsequent input from members of the EDTC and DMAC committees and from several non-European members of the Pisa Initiative.[2]

Those documents have been reviewed by the members of the Joint Educational Subcommittee of the ECHM and the EDTC.[3] Training Objectives for a Hyperbaric Medicine Physician were added (initially prepared by Wilhelm Welslau and Jacek Kot). Based on modular structure of the training course, teaching hours which are necessary for fulfil those training objectives were proposed for both level 2D (Diving Medicine) and level 2H (Hyperbaric Medicine).

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[1] At this time the Joint Educational Subcommittee of the ECHM and EDTC was formed by Jordi Desola (Spain), David Elliott (United Kingdom), Pasquale Longobardi / P. Pelaia (Italy), Francis Wattel (France), and Juerg Wendling (Switzerland). It was chaired by Jordi Desola on behalf of the ECHM and Juerg Wendling on behalf of the EDTC.

[2] L'Abbate A, Elliott D. *The Pisa inter-university initiative for the medical and physiological support of complex and deeper diving*. Diving and Hyperbaric Medicine. 2009; 39: 110-111.

[3] At this time the Joint Educational Subcommittee of the ECHM and EDTC had five members: Jordi Desola (Spain), David Elliott (United Kingdom), Juerg Wendling (Switzerland), Pasquale Longobardi (Italy), Alessandro Marroni (Italy), Wilhelm Welslau (Germany) and Jacek Kot (Poland).

1. Introduction

These training standards are the result of some years of international discussion which began prior the 1st European Consensus Conference on Hyperbaric Medicine, Lille, in September 1994 where one session was devoted to "Personnel education and training policies". A comprehensive paper by Jordi Desola and the subsequent debate defined the 5 different personnel categories ideally involved in the staff of a Centre of Hyperbaric Medicine:

- the medical doctors, including the Medical Director
- the nurses,
- the attendants,
- the chamber operators, and the
- technicians.

The definition, functions, background, academic requirements, dedication, and the continuous education, of each category were agreed (see: www.ECHM.org). A working group has been formed to define the requirements for medical doctors in the fields of diving and hyperbaric medicine. An important feature of this project was the collaboration between the European Committee for Hyperbaric Medicine (ECHM), which is primarily a medical committee, and the European Diving Technology Committee (EDTC) which is a 15-nation committee with not only government, industry and trades union representatives but also with a doctor nominated from each member country. The Goal-setting Principles for Harmonised diving Standards in Europe was published by the EDTC in 1997 and includes a section on the "Qualifications, education and training of medical doctors" (see: www.EDTC.org). This document also defines the different personal categories involved in on-site chambers and bells for diving operations.

The version presented here has been edited by the Joint Medical Subcommittee of these two main committees and, from time to time, reports by this Subcommittee have been submitted to and approved by each of the two parent bodies.

It is the purpose of this paper to summarise what has been accomplished and to look at the future tasks of a Joint Medical Subcommittee of the ECHM & EDTC.

2. Definition of jobs

Before any consideration of a training programme, the training objectives of each job need to be defined in relation to the competencies that are expected from the incumbent. A number of the jobs in diving and hyperbaric medicine have tasks and objectives in common and so it is possible to optimise the efficiency of the educational program and avoid too much overlap by adopting a modular structure. Thus first we define the jobs which are compatible with the other EDTC and ECHM standards:

Level 1. "Medical Examiner of Divers" (MED)

- Competent to perform the "Fitness to dive assessments" of working and recreational divers and compressed air workers, except the resume diving assessment of after major decompression incidents.

Level 2D. "Diving Medicine Physician" (DMP)

- Competent to perform the initial and all other assessments of working and recreational divers or compressed air workers.
- Can manage diving accidents and advise diving contractors and others on diving medicine and physiology (with the back-up of a diving medical expert or consultant).
- Should have knowledge in relevant aspects of occupational health. He or she does not need to be certified specialist in occupational medicine to be in accordance with the standards, but it is recommended also for those of Level 1 who examine commercial divers and compressed air workers.
- Should have certified skills and basic practical experience in fitness-to-dive assessment, management of diving accidents, safety planning for professional diving operations, advanced life support and acute trauma care as well as general wound care.

Level 2H. "Hyperbaric Medicine Physician" (HMP)

- Responsible for hyperbaric sessions at the treatment site (with backup of a hyperbaric medicine expert or consultant)
- Should have appropriate experience in anaesthesia and intensive care in order to manage the HBO patients (he or she does not need to be certified specialist in anaesthesia and intensive care to be in accordance with the standards)
- Competent to assess and manage clinical patients for HBO treatment

Level 3. "Hyperbaric medicine expert or consultant (hyperbaric and diving medicine)"

- Competent as chief of a hyperbaric facility (HBO centre) and/or to manage the medical and physiological aspects of complex diving activities.[4]
- Competent to manage research programs.
- Competent to supervise his team (HBO doctors and personnel, health professionals and others).
- Competent to teach relevant aspects of hyperbaric medicine and physiology to all members of staff.

IV. "Associated specialists"

- This title is not a job qualification, but rather a function. It covers experts, consultants and specialists of other clinical specialities who can be nominated as competent to advise within their own speciality upon specific problems in the diving and hyperbaric field.

[4] Optional additional qualification for bell diving (saturation, mostly off-shore).

3. Training programs

This chapter describes the principles of training to the level of competence required for the jobs defined in Chapter 2. As the jobs need a certain amount of knowledge and theoretical basis, but also practical skills and basic experience, the following training steps using a modular approach are proposed:

- Course level 1 "Medical examiner of divers" (diploma)
- Course level 2D "Diving medicine" (diploma)
- Course level 2H "Hyperbaric medicine" (diploma)
- Individual applied training (clinical on-site or performing skills training modules and specialised courses) to achieve the practical experience and skills for a certificate of competence as diving medical physician (2D) or a certificate of competence is hyperbaric medicine physician (2H).
- Final assessment for certification as diving medicine physician or hyperbaric medicine physician, independent of course faculties (the goal is an international standard).
- CME: Refresher courses and skills trainings according to the agreed plans.

The Level 2D and Level 2H physician will already have the status of specialist accreditation ("board certification") in a field of clinical medicine. However, the subsequent experience that the doctor will then need to acquire and the requirements for later revision are not addressed here. Theoretical courses, even with practical exercises included in teaching hours, will not replace the clinical experience. So the level 2D and level 2H should be treated as an initial training of young physicians before getting experience in normal work at the diving site or in the hyperbaric facility.

4. Content of modules

The required competence needed for each subject differs at each of Levels 1, 2D, 2H and 3 (Table 1). Description of levels of competence is included in the Appendix 1. Training objectives for both Level 2D and Level 2H are included in Appendix 2 and 3, respectively.

Table 1. Modules with level of competence (LoC) and proposed number of hours (NoH).
Levels of competence: a – basic; b - need to know; c - must be expert.

	Jobs:	1	2D LoC	2D NoH	2H LoC	2H NoH	3
1	**Physiology & pathology of diving and hyperbaric exposure:**			**24**		**30**	
1.1	Hyperbaric physics	**b**	**c**	**2**	**c**	**2**	**c**
1.2	Diving related physiology I (functional anatomy, respiration, hearing and equilibrium control, thermoregulation)	**b**	**c**	**1**	**b**	**1**	**c**
1.3	Hyperbaric pathophysiology of immersion	**b**	**c**	**2**	**a**	**2**	**c**
1.4	Pathophysiology of decompression	**b**	**c**	**2.5**	**b**	**2.5**	**c**
1.5	Acute dysbaric disorders: a brief introductory section	**b**	**c**	**2.5**	**b**	**2.5**	**c**
1.6	Chronic dysbaric disorders (Long term health effects)	**b**	**c**	**2**	**a**	**2**	**b/c**
1.7	HBO-Basics – physiology and pathology	**-**	**b**	**4**	**c**	**10**	**c**
1.8	Oxygen toxicity	**a**	**c**	**2**	**c**	**2**	**c**
1.9	Pressure and inert gas effects	**a**	**c**	**1.5**	**a**	**1.5**	**c**
1.10	Medication under pressure	**b**	**c**	**1.5**	**c**	**1.5**	**c**
1.11	Non-dysbaric diving pathologies	**a**	**c**	**3**	**-**	**3**	**c**
2	**Diving technology and safety:**			**8**		**8**	
2.1	Basic safety planning	**b**	**b**	**1**	**-**	**1**	**a/c**
2.2	Compressed air work	**b**	**b**	**1**	**b**	**1**	**a/c**
2.3	Diving procedures	**b**	**c**	**1**	**a**	**1**	**a/ c**
2.4	Characteristics of various divers	**b**	**b**	**0.5**	**a**	**0.5**	**a/c**
2.5	Diving equipment	**b**	**b**	**0.5**	**a**	**0.5**	**a/c**
2.6	Diving tables and computers	**b**	**b**	**2**	**b**	**2**	**a/c**
2.7	Regulations and standards for diving	**b**	**b**	**1**	**-**	**1**	**a/c**
2.8	Saturation diving	**b**	**c**	**1**	**-**	**1**	**a/c**
3	**Fitness to dive**			**4**		**4**	
3.1	Fitness to dive criteria and contraindications (for divers, tunnel workers and HBOT patients and chamber personnel)	**c**	**c**	**2**	**c**	**2**	**c**
3.2	Fitness to dive assessment	**c**	**c**	**1**	**c**	**1**	**c**
3.3	Fitness to dive standards (professional and recreational)	**c**	**c**	**1**	**b**	**1**	**c**

4	**Diving accidents:**			**10**		**10**	
4.1	Diving incidents and accidents	**a**	**c**	**1**	**a**	**1**	**c**
4.2	Emergency medical support (with no chamber on site)	**-**	**c**	**2**	**c**	**2**	**c**
4.3	Decompression illnesses	**a**	**c**	**2**	**c**	**2**	**c**
4.4	Immediate management of decompression illnesses: recompression tables and strategies	**a**	**c**	**3**	**c**	**3**	**c**
4.5	Rehabilitation of disabled divers	**-**	**a**	**1**	**a**	**1**	**b/c**
4.6	Diving accident investigation	**-**	**a**	**1**	**a**	**1**	**c/a**
5	**Clinical HBO:**			**8**		**42**	
5.1	Chamber technique (multiplace, monoplace, transport chambers, wet recompression)	**-**	**b**	**2**	**C**	**6**	**c**
5.2	HBO: Mandatory Indications	**-**	**a**	**2**	**c**	**6**	**c**
5.3	HBO: Recommended Indications	**-**	**-**	**-**	**c**	**4**	**c**
5.4	HBO: experimental and anecdotal indications	**-**	**-**	**-**	**b**	**2**	**c**
5.5	Data collection / statistics / evaluation	**-**	**b**	**1**	**b**	**3**	**c**
5.6	General basic treatment (nursing)	**-**	**b**	**-**	**c**	**4**	**c**
5.7	Diagnostic, monitoring and therapeutical divices in chambers	**-**	**c**	**1**	**c**	**5**	**c**
5.8	Risk assessment, incidents monitoring and safety plan in HBO-Chambers	**-**	**b**	**1**	**c**	**9**	**c**
5.9	Safety regulations	-	**c**	**1**	**c**	**3**	**c**
6	**Miscellaneous**			**2**		**2**	
6.1	Research standards	**-**	**a**	**1**	**a**	**1**	**c**
6.2	Paramedics teaching program	**-**	**b**	**0.5**	**a**	**0.5**	**c**
6.3	Management /Organisation of HBO facility	**-**	**a**	**0.5**	**a**	**0.5**	**c**
7	**Practical training:**			**24**		**24**	
7.1	Fitness of the course participants	**-**	**+**	**2**	**+**	**2**	**+**
7.2	Practical revision of examination skills	**+**	**+**	**1**	**+**	**1**	**+**
7.3	Practice in HBO-T (including pressure test and experience of nitrogen narcosis)	**-**	**+**	**8**	**+**	**8**	**+**
7.4a	CPR	**-**	**+**	**2**	**+**	**2**	**+**
7.4b	Practice in field first aid (diving accidents)	**-**	**+**	**2**	**-**	**2**	**+**
7.5	Underwater experience	**(+)**[2]	**+**[4]	**4**	**-**	**4**	**+**
7.6a	Demo : professional diving	**+**	**+**	**4**	**-**	**1**	**+**
7.6b	Demo : HBO-T	**-**	**+**	**1**	**+**	**4**	**+**
	TOTAL:	**28**	**-**	**80**	**-**	**120**	**-**

In order to take into account the development of modern educational techniques, a credit system will be used by the accreditation body with a conversion rule ensuring that all content of the syllabus will be presented to the students regardless of the method.

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[2] recommended

[4] exceptions possible, if important reasons of unfitness to dive

5. Standards for course organisation and certification

5.1. Teaching courses

In order to comply with this EDTC/ECHM standard the person responsible for the professional contents of the course must be a hyperbaric medical expert (job type 3).

1. The course curriculum should be declared as being "in conformity with the ECHM/EDTC standards" and the educational objective (jobs 1, 2D, 2H) stated.
2. It is highly recommended that the course organisers validate their program and organisation by an external audit.[5]
3. Each course includes a final test for individual evaluation and this final test is mandatory. The assessment should cover all the taught subjects according to training objective at the level of competence required for each subject. The pass/fail criteria must be communicated at the beginning of the course and a re-assessment for those who fail should be offered.
4. The course director will hand out a "diploma" that states the successful attendance to the specific educational module. The diploma should mention that the course is in conformity with these standards (eventually also mentioning that it has been audited by the external organisation.

The standards do not prescribe the status of the teaching institution but it is strongly recommended that courses are university based, are approved for such training courses by national authorities, speciality training boards or are under the auspices of the national scientific society for diving medicine and/or hyperbaric medicine.

How a course is to be organised is not prescribed in these standards. Modular structure of the course allows flexible organisation of modules as long as organiser ensures that all modules are completed for specific level. There are many options available, like evenings, week-ends, full weeks or partial e-learning. For clinical teaching, an internship or residency may be appropriate. The acknowledgement of a high teaching standard is based on a credible final test of the candidates.

5.2. Modules and course organisation

The actual organisation and conduct of the modules will be influenced by local factors and so it is proposed that these details can be decided on a national basis and probably left to the individual course directors. The following proposal indicates the total teaching hours considered necessary to achieve appropriate competencies in the following jobs (Table 2).

[5] At present such audits are available for Level 1 and Level 2D courses from the DMAC/EDTC expert group (www.DMAC.org) and for all modules from the ECB (www.ECBM.org).

Table 2. Teaching hours for each level.

Level 1	Medical Examiner of Divers	25 lecture hours + 3 hours practical
Level 2D	Diving Medicine Physician	80 hours of training
Level 2H	Hyperbaric Medicine Physician	120 hours of training
Level 3	Diving and Hyperbaric Medicine Expert or Consultant	This needs further review (see below)

The main objective for the document has been preparation of a general scheme of education in diving and hyperbaric medicine in order to obtain a mutual recognition of competency throughout Europe and to ensure that a physician having succeeded in an educational course anywhere in Europe has really acquired the minimal level of competency we all agreed on. Any country or educational institution is free to increase the number of hours for specific courses.

Analysis of dependency between level 2D and 2H showed that those objectives which are in common with those of diving and those of hyperbaric work are mostly included in the level 2D. Moreover, modular structure of the course allows flexible organisation of modules as long as organiser ensures that all modules are completed for specific level. For example, in order to complete Level 2H those physicians who are already Level 2D Diving Medicine Physician could complete only those modules from Level 2H which are missing in the Level 2D. So the level 2o, previously called introductory, basic or common module in previous edition of ECHM education and training standards, is not any more supported.

From the educational point of view there is no real difference in training of diving medicine physicians (Level 2D) between those who will be involved in recreational diving and those who will serve as medical advisors for diving companies. Those physicians who will work in diving companies must have also training in occupational medicine[6], but this is not included in the Level 2D and must be done externally.

5.3. Recognition of an expert

The experience needed to become an expert cannot be learned from a course. The essentials have already been described in general terms. The candidate should already be an accredited specialist or equivalent. Recognition of the Expert (Level 3) by the ECHM is described in Appendix 7. While ECHM has established a certifying institution for all levels of certificates including Level 3, called European College of Baromedicine (ECB, www.ECBM.org), EDTC needs an international board of experts recognised by the international diving operators. This board will include experts of other continents in order to extend the validity of certifications and accordingly free exchange of professionals beyond the European limits.

[6] In most of European countries the occupational medicine is a certified specialty.

6. Certificate of competency and recertification

6.1. Audit of training courses and harmonised final assessment

Free movement of qualified personnel - the main goal of these standards - will only be possible if a credible authority certifies their competency of specifically trained candidate. With the definition of auditing agency for the course modules and an internationally harmonised final assessment of the candidates, this goal is almost achieved. This is in conformity with other international efforts (from USA, Australia and South Africa) and should not be limited to the geographical area of Europe. An institution supervising the validity of individual certificates and serving as identification databank should be established in the future.[7]

6.2. Logbook

The practical skills training should be monitored and validated by the certifying instance. The candidate shall have a logbook with the list of the criteria to be fulfilled and the relative weight of each action. These units added will give a score. Using this system, the candidates may compensate for some missing score points by adding surplus points from another action.[8]

6.3. Certification

Certificates of competence may be handed out by a nationally accredited institution or an internationally acknowledged agency.

6.4. Recertification

A revalidation of a specialist's status is now generally introduced in medical professionals. According to the EU-guidance, the professionals define the conditions and in an interval of 3 years[9] all certificates have to be renewed. In most of the EU-countries, the conditions for maintaining the active status of an individual are defined by some system of continuous medical education credit points (CME). The refresher seminars can serve to update the participants in order to confirm their active status and to reactivate those who temporarily have not maintained their required activity. They can also serve as an introduction to doctors of other specialities who may also gain CME credits in their own specialities. This not only can help the financing of a course but can be a chance for promoting diving and hyperbaric medicine to those who would not attend the diving and hyperbaric scientific congresses.

The training standards define the minimum requirement for this in a flexible way that provides enough freedom for the national bodies to establish a more detailed system. It is expected that these national requirements will be compatible with our guidance.

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[7] In Europe such function has been delegated to the European College of Baromedicine (ECB, www.ECBM.org).

[8] The detailed mechanism is under preparation.

[9] Until Diving and Hyperbaric Medicine is not recognized as specialisation, the proposed interval for renewing of certification is at least every 5 years or less, if defined by national regulations.

6.5. Summary

Table 3. Summary of levels - conditions for certification and recertification.

	Diploma	Certificate of Competency	Continuous medical education
Level 1 „Medical Examiner of Divers"	▪ Approved physician (w/o specialty). ▪ Successful completion of Course Level 1	▪ Diploma "Medical Examiner of Divers" (Level 1)	▪ Renewal at least every 5 years ▪ Proof of examinations of 30 divers in the last 3 years and ▪ Successful completion of a refresher course or equivalent (16 hours, content of course 1)
Level 2D „ Diving Medicine Physician"	▪ Diploma I ▪ Successful completion of course 2D	▪ Diploma 2D ▪ Attestation of skills and practical experience in fitness to dive assessment, management of diving accidents, safety planning for professional diving operations (according to a score with the logbook). ▪ Attested skills in basic and advanced life support including external automatic defibrillation (equivalent to ACLS). ▪ Certified skills in acute trauma care (equivalent to ATLS) and wound care. ▪ Basic proficiency in occupational medicine. ▪ Final assessment (internationally based, according to the Pisa initiative).	▪ Renewal at least every 5 years ▪ Continuing experience in the field of professional diving (e.g. advising a professional diving contractor or some equivalent activity or alternatively attending a skills training course) and scientific update by participation in a refresher course, congress or literature studies. Reactivation after laps should be on the basis of specifically approved course. (See Appendix 5 for details)
Level 2H „Hyperbaric Medicine Physician"	▪ Diploma 1 ▪ Successful completion of course 2H ▪ Proof of 6 months work as medical intern in intensive/critical care	▪ Diploma 2H ▪ 6 months work as medical intern in an approved hyperbaric centre	▪ Renewal at least every 5 years ▪ Continuing experience in the field of HBO therapy and scientific update by participation in a refresher course, congress or literature studies. Reactivation after laps should be on the basis of specifically approved course. (See Appendix 6 for details),
Level 3 „Expert in Diving Medicine" / „Expert in Hyperbaric Medicine" / „Expert in Diving and Hyperbaric Medicine"	*(For the recognition of Level 3 Expert by ECHM see Appendix 7)*	*(For the recognition of Level 3 Expert by ECHM see Appendix 7)*	*(For the recognition of Level 3 Expert by ECHM see Appendix 7)*

7. The Joint Medical Subcommittee of ECHM and EDTC

This committee operates as an editing group on the basis of the tasks outlined above.

The members are the two chairmen or organisation's representatives of the education and training subcommittee of the ECHM and of the medical subcommittee of the EDTC respectively. Further two to three members are nominated by the chairmen on the basis of their special competence and experience in one of the relevant topics. As the chairman, or organisation's representative, each represent a specific subcommittee, any major changes or decisions must be discussed within these subcommittees before going to the meetings of the EDTC or ECHM respectively.

The EDTC and ECHM representatives of each country should nominate a national co-ordinator of teaching programmes, who could be the joint subcommittee member himself or who could delegate for that purpose (for instance to the national health and safety authority or any representative scientific body covering all aspects of hyperbaric medicine). The national co-ordinator will have the duty to supervise the national programs, the certification procedures and the status of the course directors.

In order to enhance credibility of certification and to help those who do not yet have the experience necessary to establish a good validation system, the Joint Medical Subcommittee will create a pool of multiple choice questions with an evaluation grid, in the main European languages. This will be available for all members and will enable an unbiased and fair assessment of the trainees seeking certification. Evaluation of the answers will be done by an international group nominated by the Joint Medical Subcommittee.

For the Joint Medical Subcommittee of the ECHM and EDTC (in alphabetical order):

- Jordi Desola (Spain),
- David Elliott (United Kingdom),
- Jacek Kot (Poland),
- Pasquale Longobardi (Italy),
- Alessandro Marroni (Italy),
- Wilhelm Welslau (Germany),
- Juerg Wendling (Switzerland).

Appendix 1. Levels of competence

Current DMAC 29	A	Basic	- aware of subject
	B	Need to know	- familiar with subject
	C	Must be expert	- detailed understanding of subject

Proposed “Levels of Competence”

1. Awareness - has a sound understanding and a good knowledge of what is involved in this area of expertise and its relevance to the field
   - *Able to describe the main elements of the area of expertise and their importance to the business*
   - *Able to recognise how and where competences in the area of expertise are relevant to own job.*

2. Awareness plus knowledge - can interpret and evaluate information and advice from experts in this area of expertise.
   - *Know and able to use correctly the terminology (vocabulary) of the area of expertise*
   - *Able to hold an informed debate with experts in the area of expertise*
   - *Able to ask questions that test the viability of proposals in an area of expertise.*

3. Knowledge plus skill - able to carry out consistently the activities within this area of expertise to the required standard.
   - *Able to perform satisfactorily majority of activities of the area of expertise*
   - *Able to translate guidelines and standards for the area of expertise into practical actions,*
   - *Able to solve common technical / operational problems in the area of expertise*
   - *Able to guide and advise others in technical / operational aspects of the areas of expertise.*

4. Skill plus Mastery - able to diagnose and resolve significant, unusual problems and to successfully adapt aspects of the area of expertise.
   - *Able to creatively solve significant, complex, non-routine problems in the area of expertise*
   - *Able to adapt practices from other sources for use in the area of expertise*
   - *Able to generate substantial improvements to local practices and procedures for the area of expertise.*

Appendix 2. Training objectives for level 2D [10] [11] [12]

The purpose of this Appendix is to define more closely the training in diving that is needed by doctors already fully accredited or board-certified in a clinical speciality. The introductory level of diving medicine is for a Medical Examiner of Divers (“Level 1”) and this needs to be maintained by periodic refresher courses.

The Diving Medicine Physician (“Level 2D”) has the status of specialist accreditation or board certification in some field of clinical medicine and is required to maintain competence at Level 1 and their primary clinical speciality.

Each training objective stands on its own and does not depend on others for interpretation. This means, theoretically, that the order in which they are presented is not significant but, for convenience, they have been placed in topic groups which should be a more practical format for training providers.

Throughout this document, note also that the words of the training objectives that follow are each to be understood as beginning with this phrase:

“On completion of this training, the candidate is expected to - ”

[10] This document is based on topic headings that originally were prepared for a working group of European Diving Technology Committee (EDTC) and the European Committee of Hyperbaric Medicine (ECHM) as a guide for diving medicine some 20 years ago by J. Desola, T. Nome and D. Elliott.

[11] The current document is a guide for training course providers that is based on all the training objectives that were agreed by DMAC, EDTC and ECHM in 2010.

[12] These objectives have been applied internationally by the Diving Medical Advisory Committee (DMAC) to doctors who provide medical support to working divers. Most recreational instructors and dive guides are, by their employment, working divers and so the guidance includes the relevant aspects of recreational diving. Although the term “diver” refers to anyone who breathes at pressure from an underwater source of gas, the scope of training is greater than that. Those who work at pressure in a dry environment, such as compressed air workers, and those in deeper caissons and tunnels who use mixed gas and saturation techniques are included. Though rare, the unique problems of competitive breath-hold divers are also mentioned.

1. PHYSIOLOGY & PATHOLOGY OF DIVING AND HYPERBARIC EXPOSURE

1.1. HYPERBARIC PHYSICS

- understand Archimedes' principle, including the differences between being negatively, neutrally and positively buoyant, and apply this to the underwater working environment.
- understand atmospheric pressure, the universal gas law, general gas laws, other related gas laws (Boyle, Charles, Gay-Lussac) and be able to make all the relevant calculations, e.g. be able to calculate partial pressures, surface-equivalent values, pressure-volume and density changes at depth. Should be able to calculate the volume of compressed breathing gas needed for a given duration of specified activity at a specific pressure.
- understand Poisuelle's equation in detail, and apply the effects of changes in density and changes in diameter on air flow.
- calculate the effect upon the subsequent measurement of content per unit volume when samples taken at depth are decompressed to atmospheric pressure for analysis. Be aware that this expansion can reduce an unacceptable gas partial pressure or particulate count at depth to one that may be undetectable at the surface.
- convert between the different temperature units (degrees centigrade, fahrenheit, Kelvin and Rankin)
- understand Laplace's equation and its application to changes of bubble mechanics and bullae in the diving environment.
- understand Pascal's principle of pressure transmission in fluids and how this principle is applied to a diver in the water.
- understand the significance of temperature changes with compression and decompression.
- be familiar with converting between imperial, metric and other units of pressure used
- be aware of the need to adjust for the difference between the concept of "gauge pressure" (as still used by many engineers) and the absolute values of pressure.
- understand Henry's Law of gas equilibrium and the time dependence of gas equilibrium in fluid. (Review gas diffusion gradients in the tissues and pulmonary gas exchange)
- understand the speed, transmission and reflections of sound waves in water, the units of sound and pressure energy underwater, and their attenuation by other factors. Apply this to various underwater sources: sonar, seismic etc.
- be familiar with the effect of various breathing gases on speech distortion at depth and the limitations of "helium inscramblers".
- understand the influence of surface waves in various sea states upon transient changes of pressure on the diver at depth or on 'stops'
- understand the influence of a mask on the apparent displacement of perceived images and the effect of depth underwater on colour transmission and perception

1.2. DIVING RELATED PHYSIOLOGY (functional anatomy, respiration, hearing and equilibrium control, thermoregulation)

- understand the interactions upon underwater equilibrium of the loss of visual reference points in poor visibility and some loss of proprioception, especially if concurrent with ear-clearing difficulties
- understand the effect of hyperventilation on diver's in-water neutral buoyancy due to increased rate of physical work and minute volume

Respiratory

- explain the differences between normobaric and hyperbaric physiology (strong focus on gas physiology, gas transport, etc.)
- understand the special air-packing techniques of competitive apnoea divers that may change vital capacity and other parameters beyond physiological norms and be aware of the complications of advanced breath-hold diving. This recommendation acknowledges that this activity is outside the definition of 'working divers' but the scope enhances physiological credibility
- for the acceptance of new or modified underwater breathing apparatus (uba) understand the work of breathing, its limits and how it changes with density and gas mix
- understand respiratory external dead space as influenced by various uba circuits and helmet designs
- understand the vertical pressure gradient over the immersed chest and the eupnoic point in relation to counter-lung or demand-valve positioning
- understand the limitations imposed by increased density on ventilation and the external work of breathing
- be able to review technical reports on the adequacy of a uba (new design or in accident reports)
- understand the hazards of "Skip-breathing" to prolong scuba tank duration
- understand airway structure and hyperbaric gas flow in relation to diver velocity of ascent

Hearing

- understand the attenuation of sound at the ear when it is transmitted (i) through water only (ii) through water plus a neoprene hood (iii) through dry gas within a helmet

Thermal

- understand the physiology of thermoregulation and what determines human limits when exposed to sudden cold immersion (cold shock) or slow prolonged cooling.
- understand the responses to slow body cooling during immersion, and the relative roles of wet suits and dry suits.

- understand the advantages and disadvantages of providing thermal supplements (such as use of a surface-supplied hot-water suit) in relation to subsequent decompression safety.
- understand the respiratory loss of heat at greater depths especially in relation to gas density and the need for routine inspiratory gas heating
- recognise the hazardous rate of respiratory heat loss upon pharyngeal secretions when there is no supplementary heat available at great depths
- understand the thermal properties of the respired inert gases in relation to the increase of thermal capacity with increased pressure

1.3. HYPERBARIC PATHOPHYSIOLOGY OF IMMERSION

- understand the physiological effects of head-out immersion and supine submersion on cardiac output and tissue perfusion
- understand the hazard of hypoxia in ascent from a breath-hold dive especially if pre-dive hyperventilation has reduced CO_2 drive
- understand the synergistic effects of raised pO_2, pN_2 and pCO_2 in the causation of “deep-water blackout“ in deep air diving with hard work.
- know when and how to identify CO_2 retainers
- understand the need of training to prepare the individual to have a resiliant psychological response for stress, particularly when handling a life-threatening situation.

Endurance

- assess the maximum dive duration as predetermined by the required decompression
- consider the nature of the task, the muscular and respiratory work (as increased with greater gas density) and diver’s motivation
- recognise that maximum in-water duration of excursion from a bell by a sat diver is determined by industry guidance, eg 4 h for each man in a 2-man 8-h bell run.

1.4. PATHOPHYSIOLOGY OF DECOMPRESSION

- be aware of the development of decompression theory (beginning with, but not confined to, the work of Paul Bert, Leonard Hill, John Haldane, following through the developments by the USNavy, Buhlmann, DCIEM, and the emergence of commercial tables and the recreational developments)
- be aware of the evidence surrounding the many mathematical and other hypotheses that relate to decompression theory and calculation, and including:
    - the uptake and distribution of the respiratory gases at depth
    - effects due to the inspiration of the other so-called inert gases

  - bubble nuclei and bubble formation, growth and distribution
  - the separate role of bubble emboli arising from the alveoli
  - the implications for bubble effects of potential right-to-left shunts
  - surface activity at the blood-gas interface and its systemic effects
  - role of endothelium, blood constituents and other tissues in sequelae
- understand the basis of contemporary decompression theories (eg, deep stops, rate of ascent, gas switching) and the extent to which they have (and have not) been validated by manned testing and other techniques
- understand the concepts of superficial and deep counter-diffusion, their potential consequences and methods of avoidance
- relate the type of decompression to nature of any subsequent manifestations (Section 4.4)

1.5. ACUTE DYSBARIC DISORDERS: a brief introductory section only.

- understand the consequences of pressure-induced volume changes (barotrauma) in the various gas-containing spaces of the body
- recognise the many factors that can influence individual susceptibility to decompression illness, both acquired and natural.
- understand the different pathologies of DCI associated with
  - dissolved gas (DCS)
  - embolic gas (AGE)
  - both concurrently (Biphasic DCI)
  - the presence of a PFO or other right-to-left shunt
- recognise localised bubble formation in areas of hypoperfusion or recent injury
- understand the role of the cellular elements of blood and the endothelium in the development of DCI
- remember that the pathology of decompression illness immediately after onset is not as complex as it will become some hours later

1.6. CHRONIC DYSBARIC DISORDERS ("Long-term health effects")

Note that the neurological sequlae of acute DCI are residua that have a known cause (Section 1.5) and so are not in this group that have an insidious onsets.

General

- understand the principles of recognizing the presence of an occupational condition in a particular population of workers such as divers, of avoiding or minimising any contributory factors, of accepting any residual risk, of monitoring the population for effectiveness of control and the surveillance of individuals at risk for early diagnosis and management

Dysbaric osteonecrosis (DON)

- know the history of this condition in compressed-air workers (caisson and tunnel workers) as illustrating the subsequent application of similar occupational health principles to the bone necrosis found in divers
- understand the strength of the radiological diagnostic criteria used orignially by the Medical Research Council to establish the prevalence, the prolonged natural history and the relatively benign prognosis in most of those found to have early lesions.
- understand the management of this condition and be aware of the relatively benign significance of shaft lesions in contrast to the surgical interventions needed in some for structural collapse of the humeral or femoral head.
- understand the limitations of diagnostic screening if using less-hazardous MRI. This technique provides positive findings at a much earlier stage (classified as FICAT Stage 1) and has already led to confusion with the prevalent and more rapidly progressive idiopathic femoral head necrosis (FHN) of adult males (see Guidance in DMAC 30).
- fully understand that the pathological background to the observations that FHN may need surgical intervention within months but that similar findings in dysbaric osteonecrosis (DON) lesions are associated with only intermittent pathological stress and can remain silent for years.

CNS long-term health effects

- be fully aware of the many implications of the insidious and long-term neurological and psychological manifestations reported in compressed air workers and divers and of the evidence for these. Review the main research projects conducted in this fields during the past 20 years. Recognise the multiple dysbaric and environmental factors that may contribute to such findings and the need for maintaining continuing vigilance

Other LTHE

- be fully aware of the hazards associated with other reported long-term health effects, their prevention where feasible and the evaluation of the relevant published papers relating to
  - pulmonary function
  - deafness
  - chromosomal disruption
  - retinal angiography
  - hepatic function

1.7. HBO-BASICS - PHYSIOLOGY AND PATHOLOGY

NOTE: a diving doctor associated with any treatment chamber that also treats non-diving conditions, must also attend an HBO Level 2H course**.** Those diving doctors who have no HBO responsibilities must nevertheless be capable of managing patient care and safety at raised environmental pressure in a chamber and of using infusions and ventilators.

- understand the basic effects of HBO (vasoconstriction, prevention of ischemia-reperfusion injuries, etc)
- know the approved indications for HBO therapy and the basis on which HBO works
- apply that knowledge to the diving environment (e.g. a diver with a crush-injury of the hand) particularly in saturation.

1.8. OXYGEN TOXICITY

- understand that at a threshold partial pressure in relation to duration of exposure, O_2 is a general tissue toxin that has two principal manifestations (below) and also causes general vasoconstriction (as demonstrated) in the retina.
- understand that it also has synergistic effects with N_2 and CO_2 and may, for example, also contribute to deep underwater loss of consciousness

Pulmonary toxicity

- describe the pathophysiology of acute and chronic O_2 pulmonary toxicity
- recognise the need to monitor symptoms and pulmonary function during long exposures to elevated partial pressures of oxygen and exclude manifestations of breathing a dry gas.
- calculate the CPTD (cumulative unit pulmonary toxic dose, UPTD) over time as a guide but also to recognise the limitations of that prediction in relation to “oxygen breaks“ (i.e. normoxic interludes) in that exposure.
- understand methods of calculating CPTD for repetitive exposures (over many days) and their limitations.
- understand that if cumulative pulmonary damage occurs, it is reversible in the early stages, but that this can lead to serious and irreversible histological and other pathological sequelae if exposure persists
- clinically manage a case clearly needing oxygen therapy, but already suffering toxicity (e.g. technical diver with 1400 UPTDs presenting with spinal cord DCS)

Neurotoxicity

- understand the factors that may reduce or increase cerebral O_2 toxicity
- appreciate the seriousness to the diver of an underwater oxygen seizure with its prodromal, tonic and then clonic phases

- understand the unreliability of prodromal symptoms that are perceived as warning the diver but occur too late to be useful
- recognise the need always to check O_2 content of breathing gas and the maximum safe depth for using it.
- review the different pO_2 limits for depth exposure published by various authorities (some but not all quoting maximum durations for each exposure level) and recognise that the different perceptions of residual risk should be influenced by the nature of the dive and the equipment to be used
- understand the safety advantages when the depth of the working diver and the surface-supplied gas mixture are both continuously monitored
- consider the actions to be taken by the diver when another diver has a seizure and understand that ascent during the fit could increase the risk of secondary pulmonary barotrauma
- recognise the importance of each diver at risk having a secure airway (not merely a mouth-piece with a strap but ideally a helmet) in order to avoid drowning during a seizure
- manage a case of CNS oxygen toxicity in the chamber (with focus on provision of additional air breaks) and how to re-enter the treatment table and protect attendants)

1.9. PRESSURE AND INERT GAS EFFECTS

- be aware of the direct effects of pressure on the physiology of man and of diving animals (both surface-dwelling and aquatic) from the cellular to whole body levels. These include but are not confined to neural transmission, HPNS, the coagulation cascade, hepatic changes and pulmonary physiology. These are need to in continuation to provide improved understanding of human physiology and pathology at depth, particularly deeper than 300 m.

NARCOSIS OF INERT GASES

- understand the different theories of patho-physiological inert gas effects
- understand that all the so-called inert gases all have a physiological effect to a greater or less degree similar to that of the volatile anaesthetic agents, ie excitation that precedes irresponsibility and then unconsciousness.
- be able to use objective measures to assess levels of narcosis in another individual
- be aware of the effects of nitrogen narcosis upon decision-making at depth and the value of gaining adaptation by regular deep exposures
- be aware of the equivalent narcotic levels of the other inert gases that may be breathed intentionally or, for instance, argon unintentionally as a welding contaminant
- be aware that helium is not significantly narcotic (and is not related to HPNS)

- be aware that hydrogen is not inert but has some narcotic properties and is also biologically active besides having. Also be aware that H_2, though explosive, can be breathed safely at depth provided the O_2 content is less than 4%.

HPNS

- be aware of the manifestations and adverse effects of HPNS at depth and consider the risk of fits as demonstrated in deep animal exposure.
- understand that HPNS (the high pressure neurological syndrome) is *not* a manifestation of inert gas narcosis (as demonstrated in immersed animals breathing a liquid: oxygenated fluorocarbon)
- review the hypothetical causative mechanisms of HPNS
- understand that HPNS can be exacerbated by faster rates of compression and at warmer temperatures during compression and understand that HPNS can be ameliorated when the rate of compression is slower and the chamber is kept cool
- understand that the demonstrated amelioration of HPNS by the addition of a narcotic agent (such as 5% nitrogen) to inspired oxy-helium, can create difficulties for subsequent gas reclamation and purification and so is not used routinely.

1.10. MEDICATION UNDER PRESSURE

- provide advice on non-prescribed medication commonly used by some
- recognise that insufficient is known about the effectiveness of conventional drugs or about their side-effects when prescribed for use at deeper depths where there may be unknown interactions at depth.
- be aware that some drugs affecting CNS function may have either very pronounced or almost undetectable effects, depending on the circumstances when taken (treatment for psychiatric disorder, long term prophylaxis after successful treatment, conventional drugs for self-medication, drug abuse).
- provide a sound approach to the prescription of antimalarials in divers who may have contra-indications to one or more of the choices.

1.11. NON-DYSBARIC DIVING PATHOLOGIES

Hypothermia

- recognise the insidious effects of immersed body cooling and know the importance of rewarming (even in those who may appear dead)
- be aware that greater body cooling occurs at depth where thermal capacity of respired gas is increased at its greater density.
- be familiar with supplementary body heating (usually by hot-water suits) and need for supplementary respiratory gas heating.

- understand that if such gas heating fails at great depth and while at the usual ambient sea-temp of 4°C, there can be a rapid onset of naso-pharangeal secretions that can themselves quickly become life-threatening
- recognise hypothermia as potentially common to all diving injuries and manage it both alone and in conjunction with other problems (e.g. DCI)

Raised temperature and the risk of hyperthermia

- understand that the use of hot-water suits can lead to greater gas uptake and thus exacerbate DCI in decompression, particularly with SurD O_2 procedures
- recognise the adiabatic heat of compression can have serious effects that have been fatal, when compounded by high humidity and the inability to dump heat by sweating. .

Fauna (Marine flora are not generally hazardous but kelp may entangle a diver and marine algae may be toxic and can cause an irritating cutaneous reaction).

- understand that the nematocyst causes perhaps the greatest morbidity in divers and know how to treat cases from coral injury to box jelly fish stings.
- be aware of the poisoning hazard if eating reef fish that may contain ciguatera and that this *may* mimic decompression symptoms
- recognise injuries in some who play with sting-rays
- recognise injuries in some who feed eels (that have backward facing teeth) by hand. When biting a finger they may not willingly leave their hole and emergency intervention underwater may be needed.
- know the availability of treatments specific for venomous or spiny animals e.g. weever fish, lion-fish, sea-urchins and, rarely, blue-ring octopus or sea-snakes
- recognise hazard in the presence of larger fish and, in particular, estuarine crocodiles and hippopotami
- be able to advise on appropriate contents of diver first aid kits with respect to the management of these hazards

Some other injuries and accidents

- manage acute illness or trauma sustained in the water and when there may be an obligation for some decompression stops. (A similar event that occurs at depth in saturation diving will be discussed later.)
- treat near-drowning and recognise that after an apparently successful recovery from near-drowning, there can be a later onset of a potentially lethal secondary drowning
- manage sequelae of oil-mist contamination of breathing gas
- recognize salt-water aspiration syndrome (SWAS) as a risk in: choppy waters, especially with leaky regulators etc, in a differential diagnosis of immersion accidents and manage appropriately

- be aware that marine pathogenic bacteria that may infect a diver's wound are different from those at surface and, if culture and antibiotic sensitivities are necessary, the pathologist should be advised of the marine source
- be aware of the need for immunisation or other prophylaxis (e.g. for leptospirosis)
- manage suspected carbon monoxide poisoning sustained underwater from contaminated compressed air
- manage exposure to in-water chemical pollution, contaminated mud, volatile hydrocarbons and carcinogens such as epichlorhydrin
- manage exposure to contaminants in the chamber
- manage medical aspects of overseas travel and the potential influence of anti-malarial and other drugs
- manage sea-sickness and understand the impact of this and of its medications upon the diver and potential safety (e.g. how to vomit underwater?).

2. DIVING TECHNOLOGY AND SAFETY

2.1. BASIC SAFETY PLANNING:

- be aware that by working dive procedures are likely to be influenced by government rules that have significant variations between countries. Provided such rules are not broken, many diving companies will follow other industry guidance that often is more stringent.
- understand the greater constraints upon a working diver than on a recreational diver, including the need to
  - complete a specific task effectively
  - follow agreed procedures and emergency procedures
  - dive where and when required to do so.
- understand that the diver is responsible for aspects of his/her personal safety and for own physical fitness
- understand that after the working diver has passed the annual medical examination to confirm fitness to dive, he/she still has the responsibility to report via the local medic and/or supervisor any subsequent changes or illness
- be aware that the working diver is usually under the direct control of a surface supervisor and that line-management has responsibilities for health and safety
- understand the importance of formal pre-dive checks
- revise the basic principles of occupational medicine
- reinforce the need for workplace assessment (and not only when underwater).
  - hazard recognition
  - hazard assessment
  - risk avoidance
  - risk control.

  - acceptance of residual risk.
  - understand the importance of keeping permanent records.
- be aware of known hazards such as:
  - physical: noise, radiation, electric fields, vibrating tools
  - biological: such as leptospirosis or the esturine hippopotamus
  - chemicals: solvents, contaminant gases e.g. H_2S, solvents, petro-chemicals, lead, ultrafine welding particles, degraded mud
- implement the need for individual health surveillance following exposure.
- identify the role of safety awareness and safety manuals by the employers of divers and by the recreational diver training agencies. Evaluate the effectiveness of different requirements for health protection and monitoring.
- be knowledgeable about, and able to evaluate, the general administrative methods of safety management and monitoring used in industry.
- review the misleading ambiguities of industrial LTI ("lost time injury") reporting
- be able to implement a monitoring system to show continual improvement of safety indicators (with specific focus on medical consequences)
- be aware of the potential role of anonymous reporting
- check the availability and experience of medical advisory and emergency hotlines

2.2. COMPRESSED AIR WORK

<u>Compressed air work</u>

- understand the nature of compressed air work in the dry without any immersion effects (also known traditionally as 'Caisson work', Tunnelling' and in the USA where the workers are known as 'Sand hogs')
- recognise the historic significance of early epidemiology of, for example, decompression sickness and bone necrosis because of the availability of large numbers of exposures
- understand the nature of hard physical work in regular shifts in a hot humid environment with possibility of a CO_2 build-up
- review the nature of their decompression procedures that include surface decompression and some differences from tables used by divers
- recognise the occasional need for mixed gas saturation techniques to service the drilling shield in deep but normobaric tunnelling work

<u>Air chambers</u>

- review operational procedures for dry diving and therapeutic chambers
- review chamber safety, particularly fire risks and oxygen
- recognise that the dry chambers are largely associated with, but not confined to, surface decompression and recompression.

- be aware that breathing air in dry chambers as attendants with patients or for training is routine. Attendants may need to follow oxygen-breathing as prescribed for them in the tables.
- the availability of medical equipment for an operational surface decompression chamber should be audited by a Level 2D diving doctor (see 2.8).

2.3. DIVING PROCEDURES

2.3.1 WET BELLS AND STAGES

- understand that the use of an open stage or 'wet' bell, in which the diver is exposed to the ambient pressure of the sea, is primarily for conducting prolonged decompression stops by working divers. (Some wet bells carry nitrox or oxygen for shallow stops.)
- understand that, suspended from a surface boat, the vertical range of movement of the stage or bell through the water during stops may be greater than that experienced by a diver who hangs onto an adjacent shot rope in the water.

2.3.2. SCUBA DIVING (air and mixed gas)

- understand the advantages and limitations of scuba techniques, particularly for working divers, including recreational instructors, of
  - being independent of surface control and reliable communications
  - having a finite gas supply (with/without a reserve bottle)
  - the 'buddy' principle that needs to be followed *versus* solo diving
- be aware of the need to correlate gas capacity of tanks with minute-volume needs and predicted decompression times
- be aware of the many in-water procedures relating to
  - tables and personal decompression computers
  - rates of ascent and use of a safety stop
- be familiar with in-water emergency procedures (such as recovery of an unconscious diver with a decompression obligation) and with associated equipment and procedures (such as buoyancy aids, signalling)
- understand the rare but real hazard of carbon monoxide contamination of compressed air tanks, testing procedures for CO, its diagnosis and treatment
- understand the use of nitrogen mixtures with enriched oxygen in scuba and associated depth limits. Nitrox gas mixing and filling techniques.
- understand the use of special gas mixtures in separate cylinders for sequential use in deep self-contained diving is one of several "technical" procedures taught by recreational instructors.
- recognise that the term "Technical diving", as used predominantly by advanced recreational divers, is applied to any category of dive in which the inspired oxygen content changes while

in the water. This covers different procedures and equipment and is *per se* not an adequate descriptor of technique.

- be aware of other scuba diving procedures (used by some diving scientists and camera-men) the such as:
  - prior placement of reserve tanks for lengthy penetrations
  - availability of 'hanging tanks' for decompression stops
  - feasibility and hazards of 'drift decompression'

2.3.3. SURFACE-SUPPLIED HOSE DIVING. This may be undertaken from the surface wholly in the water, or from a stage or a wet bell. (Deep short-duration "bounce" hose dives that begin from a closed-bell capable of transfer-under-pressure are considered later, with saturation diving.)

- note that, for air or oxygen-rich nitrox diving, hose diving possibly from a stage or wet-bell, is considered by most authorities as being much safer than using scuba. Some national regulations also permit oxy-helium hose procedures with a stage or wet bell to be used deeper than 50m but with some limits of duration. All hose divers need also to carry a reserve or 'bale-out' bottle.
- understand the safety advantages of a having
  - a hose as a strong tether
  - depth monitoring by the surface supervisor
  - an unlimited gas supply if trapped
  - continuously available communications
  - review surface decompression procedures (later)

2.3.4. STANDARD DIVING Note that this equipment is no longer permitted for working divers in most countries because there is no provision for a breathing reserve in case the surface gas supply fails. However it is still used in some countries (and also by some amateur historical enthusiasts).

- understand advantages and limitations of this equipment.
- be aware that the diver's gas supply pressure is determined at the surface and so specific risks include squeeze, should the dive fall uncontrolled through the water column.
- uncontrolled blow-up, feet first, has also been fatal.

2.3.5. REBREATHER DIVING (semi-closed and closed circuit)

- understand the advantages and limitations of the different configurations of self-contained breathing apparatus.
- be aware that rebreathers have been used since 1870 by working divers for tasks not suitable for standard equipment. Though depth-limited they were also used by most military divers in

WW2 as their primary equipment and still have an important military role. They are also used by some camera-men, scientists and recreational instructors.

- understand the principal differences between
- closed circuit pure oxygen
- constant-mass flow, semi-closed oxygen-rich oxy-nitrogen pre-mix
- constant-mass flow, semi-closed low-oxygen oxy-helium pre-mix (FGG3)
- tidal-volume proportionate replacement, semi-closed pre-mix
- self-mix apparatus with inert bottle and electronic-control of oxygen level
- understand the extensive training and maintenance requirements needed to use safely the electronic self-mix rebreathers
- recognise that deep commercial diving may use conventional demand valves but the exhaled gas is then returned to the surface for purification and re-use. This follows similar principles as rebreathers but requires no specific diver input.

2.3.6. OTHER DIVING PROCEDURES

Underwater habitats

- although practical procedures have been established, particularly by NOAA scientists, this would deserve supplementary review if re-introduced.

Surface decompression

- understand the procedures based on the historic use of ‘crash surfacing’ for salvage where strong tides did not permit in-water stops but where a deck chamber was available for recompression within 5 min of surfacing. This procedure continues to be used routinely in military and commercial diving.
- know the procedural constraints for enhanced safety and the HSE studies that have shown it to be at least as safe as in-water decompression.
- be aware that the use of ’hot-water suits’ at depth may increase gas uptake and affect safety of SurD chamber decompression
- be aware that the operational chambers that are used for this procedure require supplementary items of equipment for a medical emergency (see 2.2).

Nitrox and oxygen decompression stops

- be aware of the advantages and limitations of breathing oxygen-rich mixtures and/or oxygen when on in-water decompression stops following air or heliox hose diving.

Scientific projects

- recognise that scientists who dive in their work usually do so within codes of practice that also outline the assessment of exceptional techniques (such as diving within trawl nets)

<u>**Deep bounce diving**</u>

- that uses a diving bell for short mixed-gas deep dives and which is capable of transfers into a saturation system is considered with saturation diving

<u>**Saturation diving**</u> **-** will be detailed in the next section but this stage

- understand the commercial advantages of saturation diving as the technique required by many jurisdictions for diving deeper than 50m but which, for technical reasons, may also be used at shallower depths.

2.4. CHARACTERISTICS OF VARIOUS DIVERS

- **recreational divers** dive only for personal reasons and receive no cash or other reward for doing so. Understand that they can choose when and where to dive or, indeed, choose not to make a planned dive. Some recreational divers dive in caves, wrecks or deep water with advanced rebreathers and multiple gases, but at their own risk
- **working divers** are professional divers who may be employed either
  - full-time as divers or
  - primarily for other tasks, some of which include diving
- **breath-hold apnoeic diving**, if competitively extreme, may require medical support at the Level 2D level but, by law in many countries, it is not recognised as diving because no gas is breathed at depth.
- **caisson workers, tunnellers and others in compressed air** are not divers because they work at pressure in a dry environment. Thus they avoid the physiological problems associated with a hydrostatic pressure gradient over the body but they do have many medical problems that are similar to those of divers. Some deep bridge building and tunnelling has taken these workers to mixed-gas exposures as deep as 70m. Like those who have to enter very dense fluid (bentonite) to service a deep tunnel-cutting shield may have been recruited as saturation divers.
- **astronauts** are trained in water at depth to experience weightlessness and ergonomics and when doing so are diving at that time and are provided with safety divers. (Hypobaric conditions, especially spacewalks, expose the astronauts to decompression and barostress beyond this curriculum.)

2.5. DIVING EQUIPMENT as used to c.50m (see also Chambers, 2.2 & 2.8)

<u>**Breathing apparatus**</u>

- understand the physiological and respiratory acceptance criteria required for both laboratory and manned testing of new or modified underwater breathing apparatus before it is released as ’safe’ for operational use

- understand how breathing resistance induces changes in respiratory pattern (e.g., diminished respiratory minute volume with increased dead space, increased gas density or increased work of breathing)
- become familiar with the working principles of all types of breathing apparatus and understand the nature and consequences of foreseeable malfunctions

Diver monitoring

- be aware of individual on-line recordings by some companies of in-water depth-time profiles during surface-supplied dives. The on-line monitoring of depth-time profiles on screen continues to be a useful dive management tool for some supervisors. They have also been helpful in the investigation of in-water seizures. However their objective, the analysis of the decompressions that precede DCI, has been frustrated by a relative lack of decompression incidents.
- be aware of requirements for continuous in-water and in-chamber monitoring and recording of saturation-excursion dives, including the sound of breathing and communication of each diver on independent recordings tapes from in-water helmet-mounted cameras and ROVs.
- in-chamber video recordings and the need for these to be retained for an agreed duration after safe completion.
- understand the need for continuous monitoring at depth of chamber, bell and welding habitat atmospheres with alarms for the early detection of contaminants

Tools

- understand the effect of neutral buoyancy on the safety of tool use and the problems of in-water ergonomics in tool design
- be aware of injury hazards due to HP water-jetting, burning-torches, pressure differentials etc
- safety assessments must consider the relative isolation of an injured diver

Thermal

- understand the working of thermal protection and the need for heating inspired gas at depth
- understand the potential problems of scalding from hot-water suits, and the potential contamination carried by that hot-water supply.

Other equipment

- understand the hazards associated with compressors and gas mixing devices, gas storage and delivery, control and recovery in hose diving.
- understand the design and use of totally protective suits for diving in contaminated fluids.
- be aware that sat divers equipment should include
    - bail-out UBA that needs to be heated,
    - neutrally buoyant umbilical with pre-determined length some 3 metres shorter than the standby's umbilical,

- helium unscrambler,
- tools designed for wearing gloves etc,
- harness with lifting becket for emergency recovery from the water

2.6. DIVING TABLES AND COMPUTERS

NOTE that a detailed mathematical knowledge of decompression theory, while of great interest, is not essential to the practice of diving medicine (other than in some medico-legal cases)

Decompression theory and tables

- be aware of complexity and limitations of decompression theory (section 1.4). Review the further development of mathematical modelling and the many associated theories, but in summary only. In this context consider the limited manned testing of new tables, the problems met when applying them with no fudge factors and the *ad hoc* modifications made by diving companies, some navies and individual divers to improve safety.
- know that diving at altitude requires compliance with special decompression adjustments
- know the DAN, DMAC and other recommendations related to the interval needed before flying after commercial or recreational diving and the limitations of that data
- be aware of rules governing repetitive diving
- be aware of the rules regarding upward and downward excursions from saturation depths (*covered later*) including shallow oxy-nitrogen habitats.
- be aware that over the years all commercial tables have tended to converge by trial and error towards pragmatic solutions that seem to work.
- while adherence to the given tables is appropriate, be aware that interpersonal variation means some hits within the safe zone and others who, but not always, go way beyond the limits seemingly safely (but see long-term health effects

Decompression computer

- understand that mathematical modelling is the basis of a diver's individual decompression computer. Although subject to reservations mentioned above plus built-in safety factors, it can achieve an acceptable level of safety and relatively safe decompression solutions
- but be aware also that individual computer-based solutions by deep recreational divers for decompression timings and gas requirements are never fully immune to DCI

Decompression risk

- understand the concept of risk in relation to computer and table usage
- realise that compliance with accepted tables does not always prevent DCI
- realise also that to go beyond the safe limit does not mean inevitable DCI.

- understand the implications of informal changes to decompression profiles may have hidden implications on the risk of DCI (e.g. to add a “deep stop“ might protect for spinal cord DCI to some extent, but perhaps at the expense of greater uptake in slower tissues).

2.7. REGULATIONS AND STANDARDS FOR DIVING

- be aware of the wide variety of national regulations that relate to working divers around the world (some have prescriptive rules on details whereas others ascribe management responsibility to all participants for their outcomes)
- identify regulations and Codes of Practice (COPs) that are relevant to the nationalities of course attendees and how these relate to international codes of practice and recognise the importance of these where there no regulations
- be aware of international guidance that is related to recreational diving, its possible lack of legal authority but its relevance to cases in the civil courts
- maintain expertise by maintaining familiarity with current research and also not ignoring the mass of relevant data and experience available in pre-electronic books and international series of underwater symposia.

2.8. **SATURATION DIVING.** In this context it is relevant that commercial saturation diving is conducted by those who began their career as working air divers and who continue air diving as may be required.

2.8.1. SATURATION MODE

- The history of saturation development: US Navy research (George Bond) leading to seabed habitats of Man-in-Sea (Ed Link), Conshelf (Jaques Cousteau) and Sealab (US Navy). Shallow seabed habitats (mostly NOAA).
- The start of commercial saturation (Westinghouse: Smith Mountain Dam) and further development into the North Sea and worldwide. Commercial development to ca.350 m.

2.8.2. PHYSIOLOGY OF DEEP EXPOSURE

- The effects of pressure on aquatic animals living at depth and on diving animals normally at or near the surface.
- Cellular effects. The mechanisms and manifestations of HPNS, with its convulsive and other hazards.
- Laboratory studies on man to as deep as 700 m. The origin of potential long-term sequelae of deep exposure and need to define depth limits

2.8.3.COMPRESSION

- understand factors, such as a cool environment, that ameliorate HPNS during slow compression and rest periods
- review the rates of compression that have been evaluated
- assess the use of added gaseous nitrogen to ameliorate HPNS

2.8.4. AT DEPTH IN LIVING CHAMBER

- understand the challenge of maintaining O_2 within narrow partial pressure limits at great depths.
- understand the methods for continuous chamber and bell monitoring for contaminants. Be aware of how a threshold limit for a given substance measured per unit volume at the surface needs to be diminished at depth proportionate with the compression and increased partial pressures at depth and review techniques for measuring trace contaminants at depth. (Note that expansion of samples taken from depth to atmospheric pressure can reduce some contaminants from their toxic threshold at depth to less than their level for simple detection.)
- review the clinical management in saturation of coincidental illness or injury when arising at depth from:
    - injury in the water (e.g., crushed chest / traumatic amputation)
    - illness in the chamber (e.g., acute abdomen, CVA)
    - injury in the chamber (e.g., evisceration over toilet seat)
- understand the contingency measures required for the management of an offshore diving accident, particularly serious illness or injury within a saturation chamber and the preparations needed in advance to provide prolonged medical and surgical support at depth
- the need for:
    - a diver medic in each sat team;
    - reliable 24h communications ashore,
    - duty MO available to fly out.

2.8.5. BELL EXCURSIONS

- consider the clinical management of illness in the water (e.g., wrong gas)
- understand emergency procedure for ill or injured diver out of a bell:
- rescue by flooding plus man-lift or winch,
- resuscitation in the vertical or semi-recumbent mode;
- first aid by bellman;
- recognise need for a ’lost’ bell to have through-water communications and tapping code, transponder, enough gas and water for > 24h,
- be aware of risks of using bell’s weight release if fitted

- understand the urgency of heat conservation. Review passive insulation of bell and diver, plus respiratory heat exchange and limited active heating of bell by supplementary heat,
- if a 'lost' bell cannot be recovered easily expect to be asked for medical prediction on survivability prognosis and physiological aspects of rescue methods.
- understand emergency evacuation of a split-level sat system using accelerated decompression into hyperbaric lifeboat (HRV) with atmosphere control. Serious hazards of seasickness, dehydration, gas contamination, secondary injury and, with supplementary heating and survival suits or cooling, some risks to thermal balance prior to onshore recovery.

3. FITNESS TO DIVE

3.1. FITNESS TO DIVE CRITERIA AND CONTRAINDICATIONS (for divers, tunnel workers, HBOT chamber personnel *but note that HBOT patients are not included here*)

- consider each organ system in relation to diving: cardiovascular, pulmonary, urogenital, neurological, skin, etc.
- be able to interpret and apply the published clinical recommendations in relation to the fitness assessment of an individual diver or pressure worker
- be able to incorporate recent risk-based assessment in medicine into fitness for diving work, e.g. cardiovascular risk scores
- understand the different needs of fitness assessments between those in long-term employment as divers or working at raised envoronmental pressure, and those who dive only for their own recreation
- be able to assess the effects of prescribed and self-administered medications upon diving
- consider underlying patho-physiology and side effects of the drugs (eg anti-malarials) when diving
- consider the effect of environmental pressure on pharmacological actions
- assess the hazards of substance abuse and illicit drugs (recognising that for many employees this means dismissal)
- assess the impact of HIV status on diving and lengthy stays in saturation
- be able to explain to the non-diving clinician the critical aspects of a diving or pressure-exposure that may be relevant to an individual being referred for consultant opinion.
- be able to assess fitness to return to diving or pressure exposure following illness or injury for which, inevitably, there are very few criteria
- be aware of factors influencing personal DCI susceptibility (e.g. post-dive exercise)
- be aware of conditions in divers, such as the risk of 'overwhelming post-splenectomy infection' (OPSI), that preclude their isolation in saturation diving

- conduct health surveillance as indicated by the nature of the diving history eg, dysbaric osteonecrosis, where the condition may affect a future diving status
- be fully aware of the influence of immaturity, youth, disability or old age upon the safety factors that need to apply in diving, particularly in recreational diving,

3.2. FITNESS TO DIVE ASSESSMENT

- be competent to perform, apply and/or interpret the clinical and physiological investigations needed to assess fitness of the working diver and others, as defined in authorities' guidance
- be able to perform and interpret lung function tests (pre- & post exercise; pre- & post bronchodilator) blood gas analysis, and to read and interpret a chest x-ray
- be able to interpret stress-ECG examination; audiometry;
- so that divers can be referred appropriately, have a good understanding of the application of tests such as: DPOAE, plethysmography, ENG, etc.
- know the indications for and be able to perform or interpret PFO screening (Doppler) on cases and then refer cases for echo
- have a clear understanding of the role and application of "functional assessments" as performed by occupational therapists and how these should be applied to divers.
- be able, if requested, to assess the fitness of a recreational diver, to use own clinical judgement and follow appropriate guidance to reach a justifiable conclusion

3.3. **FITNESS TO DIVE STANDARDS (professional and recreational)** Although the same at Levels 1 and 2D, both basic and periodic revision, the teaching styles may differ.

- be aware that employer organisations may require a higher pass standard that many national legal minimum requirements for working divers
- be aware that a CEN norm exists concerning fitness for recreational diving.
- be aware of specific legislation existing in many countries, where "disabled" persons should be accommodated in workplaces where it is safe to do so.
- be aware of the different legal requirements for fitness of working divers that are specified by various national authorities and ensure that all have been met or exceeded
- be aware that the physiological ranges for normal pulmonary function varies between ethnic groups
- be aware that recreational training agencies may be required to follow some local regulations but that many set their own criteria, some of which may be minimal.

4. DIVING ACCIDENTS

4.1. DIVING INCIDENTS AND ACCIDENTS

- understand that in recreational diving, loss of control usually begins with diver error whereas in a working dive here are many additional contributory factors. The consequence of diving accidents may be trivial, cumulative or catastrophic.
- recognise that incidents may occur
  - on descent eg ear barotrauma;
  - at depth eg respiratory gas effects
  - on ascent eg pulmonary barotrauma, or
  - at any time eg equipment failure; coincidental injury
- understand that factors may include
  - environment (eg poor visibility or inadequate surface support)
  - the diver (eg CO_2 build-up or concealed medical problem)
  - equipment.
- understand the importance of familiarity with all emergency drills at depth
- identify emergency resources available. For diving work some authorities require a dedicated chamber on site or, for some activities, within two-hours travelling time. Prepare and rehearse emergency procedures that will follow triage principles 'emergency', 'urgent' or 'timely' et cetera.

4.2. EMERGENCY MEDICAL SUPPORT (WITH NO CHAMBER ON SITE)

Note that CPR is covered by requirements outside this guidance, e.g. Advanced Life Support (ACLS) etc and so is not repeated here.

- assess a diver recovered from the water for omitted decompression and/or barotrauma and their implications. Also assess for hypothermia.
- recognise clinically that a number of serious accidents (e.g. propeller trauma) cannot be moved easily or may not be suitable for recompression,
- understand the need to plan for the logistics of emergency medical care before diving in remote locations. Consider contingency planning for evacuation, the local availability of treatment gases, life support equipment, medications etc and of a recompression chamber and other medical support – before the trip.
- recognise the need for complete and accurate communication between those present and a remote adviser or provider
- consider the earliest time for evacuation or travelling by air
- be compliant with the ethics of the doctor-patient relationship and the need for signed consent for therapeutic intervention. These are appropriate even when the treating doctor is remotely located

- keep personal log of communications, assessment, treatment and outcome

4.2.1. BAROTRAUMA : ORL or ENT; dental; cutaneous, conjunctival, etc

(Pulmonary decompression barotrauma is considered with D.C.I.)

- understand the pathology of compression and decompression barotrauma in the head and neck region.
- recognise and treat ORL / ENT events in the chamber or at the surface
  - external ear and tympanic membrane with ear-plugs or a hood
  - middle ear with poor equalisation
  - round window and inner ear effects
- recognise the effects of “squeeze”
  - of a mask upon the conjunctiva
  - of a dry suit on the skin
  - of an uncorrected descent on the chest of a Standard Diver
- recognise crepitus in the anterior triangle of the neck as a sign of pulmonary decompression barotrauma *(reviewed elsewhere)*

4.2.2. PHYSICAL INJURIES

- recognise the very different injuries that can be inflicted by various marine animals and, for those that sting or are venomous, know the specific first aid and definitive treatments
- understand that marine pathogens have different characteristics from terrestrial ones
- be aware that injuries from underwater tools, especially of the hands, are not uncommon among working divers.
- be aware of hazards in-water field forces from impressed currents
- understand the significance in some divers’ hands of the occasional retrograde neural sensitivity to subsequent in-water cold, its assessment and methods for control.
- realise that significant underwater explosions can cause pulmonary barotrauma and manage accordingly
- know that an injury from a water-jetting gun may have only a small entry wound but that the damage may be extensive internally.
- be able, perhaps together with an experienced supervisor, to assess the ability of an injured diver after recovery to comply with all emergency procedures before a return to operational diving

4.2.3. ACCIDENT INVESTIGATION OF DIVING ILLNESS OR INJURY,

- know the procedures that divers and diving doctors should follow to secure evidence on the causation of any diving accident or illness.

- be able to advice a pathologist involved particularly if interpreting the significance of bubbles at autopsy

4.3. **DECOMPRESSION ILLNESSES**

4.3.1. PATHOPHYSIOLOGICAL BASIS AND MECHANISMS OF DCI

“DCS”

- musculo-skeletal manifestations of DCS, and how the presentation can then guide management, e.g. joint pain that is deep and changes with movement *vs.* superficial pain and no change with movement.
- cutaneous manifestations associated with decompression (“les puces“; rashes)
- lymphatic disorders (local oedema)
- fatigue and malaise
- respiratory DCS (“chokes“)
- peripheral and central neurological deficits (including “staggers“) and particularly the distinction between ’spinal’ and ’cerebral’ DCS and understand the different theories of neurological decompression illness (e.g. spinal cord DCS as embolic, venous stasis, autochthonous bubbles, watershed theory, etc),
- hypovolaemia

“PB” & “AGE”

- understand the pulmonary, systemic and neurological pathophysiology and sequelae of decompression barotrauma

Other DCI presentations

- differentiate classic gas embolism and/or decompression sickness from less common biphasic presentations and/or PFO-associated manifestations
- recognise the importance of this assessment for determining DCI treatment
- be aware of the learning value of historic accounts of different presentations and of those cases following treatments that have since been abandoned
- know the range of symptoms, signs and the patterns of presentation of DCI characteristically arising from different types of diving or chamber exposures (for instance compressed air workers in contrast to divers)

Assessment

- be aware of the practical limitations of the on-site examination of divers, e.g. with possible vertigo
- know the timescales of DCI onset and understand the significance of subsequent deterioration
- know the natural history of untreated decompression illness

- understand the importance and the recognition of symptom denial
- understand superficial and deep counter-diffusion

Examination

- know what questions must be asked of the diver, buddy and others.
- this should not delay urgent recompression if serious and deteriorating: can examine at depth (with suspected AGE in submarine escape training, an unconscious patient will be compressed first and then the doctor locked in).
- in most preferably, when the condition is stable and less serious, conduct a full (but still rapid) general examination at the surface and, especially, a complete neurological evaluation
- in all cases on arrival at treatment depth, conduct a full examination to identify the residual manifestations.
- understand the physical limitations imposed on examination when on air at 50m, particularly those related to auscultation and percussion,
- understand the limitations imposed upon a basic assessment when the chamber is too small to permit standing.
- maintain a fluid balance chart

4.3.2. DIFFERENTIAL DIAGNOSIS OF DECOMPRESSION ILLNESS

- understand that the diver may fail to report symptoms early because either the symptoms seem mild and hopefully will resolve, he/she has a fear of the social and financial consequences of reporting a symptom or it may be a true denial due to cerebral illness
- recognise that a person recovered from the seabed when unconscious may have had the wrong gas (eg CO poisoning), myocardial infarction, or has sunk down after arterial gas embolism during ascent due to negative buoyancy
- be aware of different skin disorders (e.g. suit squeeze, urticaria) that may mimic decompression illnesses -*vs*-. superficial inert diffusion -*vs*- cutis marmorata
- be aware of the difficulties of assessing subjective paresthesia, dizziness and headache
- be able to exclude other possible differential diagnoses (eg malaria, cigateura poisoning)
- be aware of immersion pulmonary oedema (with redistribution of blood flow to the central circulation and accentuation by cold-induced peripheral vasoconstriction) and of its potentially limited duration

4.3.3. MANAGEMENT OF DECOMPRESSION INCIDENTS AT THE SURFACE

- understand the value of 100% O_2 administration for suspected DCI and maintain oral hydration during evacuation
- know that nitrous oxide / oxygen (e.g. “entonox”) used for analgesia is a probable bubble amplifier

- recognise that 100% O_2 is not readily available many emergency rooms or ambulances. However, a closed system may be available for resuscitation or for the treatment of shock and is appropriate
- be aware that decompression paraplegia on surfacing has been clinically reversed almost immediately by recompression where onset has occurred right next to a diving chamber
- understand that DCS is a rare diagnosis in working divers, even though depth/time exposures are generally greater than recreational, and that in surface-supplied hose diving, AGE is almost unknown
- be aware of the various national, military and diving-company networks providing medical support in emergency for recreational, military and working diving accidents whereas the emergency rooms of many hospitals have no checklists and little or no experience of DCI management
- be aware of the special role of agencies such as DAN to educate recreational divers about the medical problems of recreational diving and provide an international network to facilitate the medical treatment of emergencies.
- be able to advise on adjunctive medical therapy, including bladder management, pressure points, etc
- understand the need for rapid transfer, especially urgent if there is continuing deterioration.
- in serious or deteriorating cases without delay consider that recompression takes priority over most investigations and paperwork
- in some urgent cases, recompression has been first and detailed examination at depth to assess residua has followed
- always conduct a medical assessment at the treatment depth as the baseline for any subsequent deterioration
- ensure the collection of relevant data for the purpose of immediate management and future follow-up

4.4. IMMEDIATE MANAGEMENT, RECOMPRESSION TABLES AND STRATEGIES

If multiplace chamber is on site

- understand the value of immediate recompression after onset to reverse manifestations almost instantly (as demonstrated by casualties of submarine-escape training). The provision of a chamber at the site
- consider recompression first, if serious and especially if deteriorating, and then an examination at depth for residua before deciding on the subsequent course.
- if distant, recognise the importance of doctor travelling to the chamber if feasible and be competent to judge when this is important.

If a one-man chamber is on site

- make a full assessment before compression
- know the limitations of access during treatment and the hazards that can be met
- understand the pressure and time limits of the tables used in these circumstances

In-water recompression

- know that unplanned in-water recompression can exacerbate DCI pathology
- be aware of successful protocols (shallow O_2) and how these are to be implemented, which pre-conditions should be met, etc.
- be fully aware of the limitations and hazards of this treatment and of the equipment preparation, planning and training needed *before* any dive begins. When previously planned, IWR (in-water recompression) is used by some dive teams in remote locations
- consider the case for in-water recompression (e.g. deep technical diver on a rebreather with no chamber in a remote area) and the associated risks.

If evacuation is needed from the dive location to a recompression centre

- understand the problems of transfer (“Medevac“) especially with altitude exposure and duration whether by plane or by road
- ensure full consultation with the evacuation team before transfer and with the receiving unit
- provide continuous oxygen, i-v fluids and other treatment as discussed with receiving unit

Table selection

- be familiar with the many treatment algorithms available, including those for cases that arise during planned decompression, those that arise after surfacing and those used in difficult cases, especially when deep or saturation chambers are available. Understand their relative merits and application of different tables.
- understand the widely-accepted algorithms available for cases arising in saturation diving and the use of oxygen-enriched mixtures at depth.

- be aware that empirically-derived treatment algorithms for compressed air workers are different from treatment tables for divers.
- be able to advise on alterations to recompressions, including adding extensions, and also changing from one table to another

Decompression on completion of treatment

- recognise the importance to the working diver of achieving a full recovery without residua on the initial recompression if he/she is to be able to return to work. If necessary extend the initial recompression to achieve this.
- recognise also that a shorter treatment followed by an overnight rest and then the next day starting a series oxygen tables, may be effective in some cases but may not provide every individual with a full resolution
- check the decompression obligation of the tender

Air-range recompression

- be constantly aware of the need to secure the maximum benefit from the first recompression because any residua will compromise diver's future employability.
- understand that an on-site chamber is an essential component of surface decompression and is an operational chamber that can be used for emergency treatment of working divers. If none available on site, pre-dive planning should identify availability of transport and suitable chamber within 2 h travelling time (as required in some regulations)
- become familiar with the wide variety of treatment protocols for decompression injuries around the world that use different pressure and oxygen algorithms supplemented by a variety of fluids and drugs. Most are usually successful but all are liable to encounter seemingly difficult cases with relapse or deterioration.
- know that the major failures of treatment are
  - failure to recognise the seriousness of post-dive symptoms
  - failure to recompress promptly
  - failure to recompress for an adequate depth and/or duration
  - failure to get an early second opinion for an inadequate response
- watch the clock but decompression should not begin until the treatment at depth has achieved its maximum benefit
- go for total relief on the first therapeutic compression (which requires a more vigorous approach than just an extended USN 6, overnight observation and repetitive shallow O_2 (Cx 12) for some days)
- in all cases of cerebral decompression illness be aware that a latent dysexecutive syndrome may not become manifest until after the completion of treatment and so it is important (at least medico-legally) that the full recompression protocol with all its extensions is followed.
- include basic ancillary care in severe neurological cases:(pleurocentesis, catheterisation, pressure points, passive range of movement (and beware venous thrombosis).

Tables for air-range DCI

- accept that there insufficient cases for the use of evidence-based analysis
- recognise that each treatment centre will be familiar with its own algorithm and prefer it.
- if adopting a diagnostic test of pressure, use at least a complete Table 6
- monitor recovery with regular checks and, if relapse occurs, return to a deeper treatment depth
- know that the therapeutic tables being used around the world within treatment algorithms should be defined by its pressure-time profile, not just its name, because there are many local variations of the originals. For instance, changes in USN Treatment Table 6A have not been universally adopted. So, following submarine escape training the ascent from 50m to O_2 at 18m (165-60 ft) can be rapid whereas, if related to gas uptake in an air dive, this ascent is 30 min. The GERS tables and the derived Comex 30 also have several versions so check the depth-time profile and specify.
- note that some algorithms are based on military needs (eg USN Diving Manual) and some alternative procedures have been adopted from Canadian, British, French and other military sources. These may not have the flexibility of alternative procedures that have been found by experience to be useful in other diving environments. Read widely
- know that in emergency, almost any air chamber can be converted into saturation with an O_2 analyser, sufficient inert gas plus O_2 supplies, with an improvised CO_2 scrubber and the availability of additional watch-keepers

Treatment of DCI from deeper surface-orientated bounce dives

(i.e. not in saturation systems - see later)

- know that there is limited experience in treating DCS from deep surface-orientated mixed gas diving.
- experience in this area has demonstrated the importance of having a chamber on site with a depth rating at least equalling that of the maximum depth.

Heliox bounce diving (in-water, or from an open bell).

- In-water decompression (max depth commercially tends to be around 70m) with no in-dive switch of inert gas). Early onset at surface treat with TT6 in air chamber but if it is necessary to go deeper, compress chamber and consider using 100% helium to reduce N2 counter-diffusion. If it was a commercial heliox dive with switches to nitrox stops, again first use a conventional TT6.
- where in some jurisdictions heliox is permitted with open bell to 300ft, use recompression with RN71 or Cx30 on heliox, possibly use a sat decompression.
- deeper recreational dives will either have been on a rebreather with a single inert, or will have used a sequence of different inert-mixes on demand. Little experience but from some military bounce dives, early TT6 could be successful.

- deeper helium bounce dives using a ‘closed’ bell raise similar issues but equipment should enable an emergency sat if necessary.
- bell “blow up” can be serious but, from very limited experience, consider depth of complete relief on heliox, if necessary to the maximum depth of dive

DCI in saturation diving

- understand that for DCI after downward excursion from storage depth compress to depth of relief immediately, possibly to the depth of the excursion, and by not less than 3 bar, consider the factors determining a stay of 12h to 24h at treatment depth, the use of oxygen rich breathing mixtures, followed by decompression with no upward excursion.
- understand that for DCI onset during the saturation decompression.
  - *if pain only*, compress slowly to depth of relief but by not more than 2 bar deeper than depth of onset.
  - *if serious*, compress promptly to at least 3 bar deeper than the depth of onset and remain for up to 6h with intermittent oxygen-rich breathing .
- be aware that these procedures have been effective deeper than 400m

Ancillary treatment

- understand importance of fluid balance (but avoid exacerbation of pulmonary DCS)
- be familiar with the guidance and developments in drug and other ancillary treatments
- be competent at depth and during pressure changes with interventions, such as ventilatory support, pleurocentesis, catheterisation, i/v cannulation, management of ETT, catheter and other cuffs, of i.v. infusions in glass or plastic bottles t, that may be needed..

In all cases

- remember the value of an early telephone discussion with another doctor experienced in this field
- know the importance of regular re-assessment at depth to detect any early deterioration.
- continue assessment for any relapse after surfacing and treat as appropriate
- for persistent residua consider repetitive O_2 therapy during recovery period
- after maximal recovery, assess when the patient may travel safely by air but be aware of the hazards of hypoxia in a neural ischaemic penumbra at altitude.
- arrange appropriate follow-up for the individual (and for statistical review)

4.5. **REHABILITATION OF DISABLED DIVERS**

After decompression injury

- understand that this task of rehabilitation usually applies to recreational diving accidents after neurological deficit. When recommended, implementation of a rehab programme is not usually the direct responsibility of the diving doctor.
- nevertheless be able to start rehabilitation processes early, especially for bladder and spinal cord DCS
- recognise that any residua in a working diver may prevent a return to diving employment,

After other accidents

- recognise that personal follow-up procedure may be crucial for avoiding PTSD or somatoform reactions.
- understand that commercial divers tend to sustain hand and finger injuries and that a return to diving is dependent on confirming their ability to perform all emergency procedures.
- a little-known feature of such injuries is a painful intolerance of cold in the distribution of the cutaneous nerves and some have been solved by directing the flow from the hot-water suit through gloves to exit at finger-tips.
- be able to apply the concepts of impairments, disabilities and incapacities to the workplace environment and advise management on policies.
- try to convince the diving companies' clients that a prophylactic recompression for omitted decompression or some doubtful symptom does not count as a Lost Time Injury or "black mark" but is good medical management.

4.6. **DIVING ACCIDENT INVESTIGATION**

Recreational accidents

- consider dives beyond the diver's competence, an error of judgement, violation of accepted procedures, an unforeseeable equipment failure, environmental factor or coincidental medical events
- ensure personal statements, obtain photos, recover and seal equipment, and ensure that dive records are collected
- get samples of cylinder gas and, in rebreathers, from counterlung
- obtain / retain / check medical records
- specify time of collection of samples of blood, urine or other specimens with a witnessed chain of custody
- photograph wounds, bites, envenomation, areas of subcutaneous emphysema
- provide specialist advice at autopsy, particularly value of a whole body x-ray but also on the lack of valid interpretation of any bubbles and their distribution; Advise pathologists as

requested with different autopsy protocols and know how these are implemented and interpreted. Check for bullae, blebs, haemorrhages of lungs and any PFO

Commercial accidents

- similar but be aware that commercial divers also sustain underwater industrial injuries (e.g. crane driver sheds load; a ship moves off station etc) *see also accident management*
- be aware that decompression illness or drowning are not the usual modes of death in commercial diving fatalities
- know that diving companies follow similar established protocols under official supervision that include retention of audio and video records. Interact as appropriate with government inspectors.
- know how to manage fatalities offshore, especially if deceased is in saturation

Accident assessment and reports

- consider medical involvement in civil litigation, third party responsibility and insurance reports
- know the principles of expert evidence and the hazards of interpretation and report writing
- be able to provide objective analysis of relevant scientific publications
- be able to review experience gained from accident investigation and civil litigation proceedings arising from previous diving incidents and the relevant sources of published information.

5. Clinical HBO

This module is dedicated mostly for the Level 2H (Hyperbaric Medicine Physician) and is described in more details in the Appendix 3. For Level 2D (Diving Medicine Physician) only chamber technique and mandatory indications for hyperbaric oxygen therapy, including decompression illnesses and corresponding recompression treatment are presented.

RECOMPRESSION CHAMBERS

Distribution and purpose

- recognise that recreational diving is relatively remote from recompression facilities. The use of chambers located in hospitals or other medical facilities follows established procedures and recompression tables appropriate for cases after an inevitable delay.
- understand that, in contrast, many working divers are required to be provided with recompression facilities on site or, if at less decompression risk, within two hours travelling time. Also understand that chambers for many commercial air-diving locations are primarily for surface decompression
- short duration diving deeper than 50m should be associated with a chamber capable of recompression to the maximum depth of that diving.

- recognise that an air chamber is not appropriate for such deeper mixed-gas diving because, if not responsive to shallow recompression, gases other than air may be needed at deeper depths, preferably with atmosphere monitoring and control.
- understand that recompression chambers should be capable of at least the maximum depth of the dive made. Saturation divers may require recompression after a downward excursion but this would be in one of the saturation chamber compartments.
- note that operational diving facilities may not be recognised as equipment for medical use and that nevertheless the standard of medical care in diving chambers needs to approach that available in a hospital HBO unit.

Chamber design and procedures

- recognise the purposes of different chamber designs (multiplace, monoplace, and chambers designed for transporting divers at pressure), their components and safe operating procedures.
- be aware of safety regulations and Codes of Practice
- be aware of mandatory and recommended HBO Indications because an injured diver may have, as examples, a crush injury or an infective cellulitis.
- understand the constraints of using of various items of medical, diagnostic, monitoring and therapeutic equipment and of ensuring good nursing care of a sick or injured diver in a chamber

6. MISCELLANEOUS

- recognise the importance of data collection / statistics / evaluation / reports
- be aware of current trends in research related to diving
- understand the role, limitations and capabilities of paramedics in this field
- understand that the management and organisation of a diving chamber is not a diving doctor's responsibility but awareness of this is needed by doctors who advise on the treatment of divers remotely

7. ASPECTS OF PRACTICAL TRAINING:

7.1. FITNESS OF THE COURSE PARTICIPANTS

- The requirement to assess the fitness of the course participants for a chamber dive: if temporarily unfit the candidate can complete the rest of course but if permanently unfit, the student will not be able to accept relevant clinical responsibilities within a compression chamber. Depending on job-description, a doctor's fitness to dive will need to be maintained in-date as long as has 'on-call' responsibilities

7.2. PRACTICAL REVISION OF EXAMINATION SKILLS

- Neurological, pulmonary function and audiology) and other systems

7.3.a. **EXPERIENCE NITROGEN NARCOSIS**

- Compression to depth (preferably to 50m on air) and illustrate the minor difficulties of mental arithmetic and communication. (If available, two breaths of Heliox at depth clearly demonstrate the level of narcosis.)

7.3.b. **SIMULATED CASES IN CHAMBER**

- For skills in medical management: treat a number of simulated diving casualties (probably at lesser depths) with the emphasis on the practical difficulties of a unit in a remote location.

7.4. **SKILLS REVISION**

- attendees are to gain appropriate life-support certificates elsewhere because in-date advanced life support training is a continuing requirement
- must be familiar with the range of oxygen provision units

7.5. **UNDERWATER EXPERIENCE**

- induce a greater respect for the working diver (cumbersome clothing, heavy gear, water entry and exit, uncomfortable breathing, poor communication, cold water and leaks)
- possibly try to use a hammer and nails underwater to make a wooden frame.

7.6. **DEMONSTRATION**S

- visit diving contractors base or on location to learn from senior divers about their work.
- visit a saturation system (rarely possible, but a Q&A session with experienced sat diver can be invaluable).

NOTE: Practice in **paramedic teaching** is no longer part of this course where this teaching is completed in nationally-approved training centre.

Appendix 3. Training objectives for level 2H

The purpose of this Appendix is to define more closely the training in diving that is needed by doctors already fully accredited or board-certified in a clinical speciality.

The Hyperbaric Medicine Physician ("Level 2H") has the status of specialist accreditation or board certification in some field of clinical medicine and is required to maintain competence at Level 1 and their primary clinical speciality.

Each training objective stands on its own and does not depend on others for interpretation. This means, theoretically, that the order in which they are presented is not significant but, for convenience, they have been placed in topic groups which should be a more practical format for training providers.

Throughout this document, note also that the words of the training objectives that follow are each to be understood as beginning with this phrase:

"On completion of this training, the candidate is expected to - "

1.7. HBO-Basics (effects of hyperbaric oxygen) ***physiology and pathology***

- understand the mechanisms of transport of oxygen in blood and tissues for hyperbaric conditions
- understand diffusion of oxygen from blood vessels to surrounding tissues under hyperbaric conditions (eg. Krogh model)
- understand the basic effects of HBO (vasoconstriction, prevention of ischemia-reperfusion injuries, etc)
- understand the toxic species of oxygen (reactive oxygen species, peroxidation of lipids, proteins, DNA)
- understand the effects of HBO on specific organs (heart, blood vessels, regional circulation, microcirculation)
- understand the effects of HBO on microorganisms, host defences against infection and antibiotic activity enhancement
- understand the effects of HBO on wound healing process
- know the approved indications for HBO therapy and the basis on which HBO works
- know the methods of tissue PO_2 measurements (polarography, tonometry, spectroscopy) and its surrogates
- apply that knowledge to the chamber environment.

5. Clinical HBO

5.1. **Chamber technique (multiplace, monoplace, transport chambers, wet recompression)**

- know the structure and operation rules for multiplace, monoplace and transport chambers
- know the structure of hyperbaric fire fighting systems
- know European regulations for hyperbaric chambers
- know methods of in-water recompression
- understand positives (short time delay, situations with no other option in "remote" locations) and negatives (dehydration, lack of monitoring, lack of medical support, further delay in getting to medical hyperbaric facility) of in-water recompression

5.2. Mandatory indications

- understand how indications are assessed to become "mandatory" (EBM methodology)
- know the levels of evidences, interpretation of those evidences and type or strength of the recommended practice for every current European "mandatory" indication for HBO therapy
- know differences between different lists of clinical indications for HBO (UHMS, ECHM)

5.3. HBO Recommended indications

- know the levels of evidences, interpretation of those evidences and type or strength of the recommended practice for every current ECHM "recommended" indication for HBO therapy

5.4. **HBO Experimental and anecdotal indications**

- know the reports and papers on experimental and anecdotal indication for HBO therapy

5.5. **HBO Data collection / statistics / evaluation**

- understand statistical methods used for data collection and evaluation
- be able to read the statistical evaluation report

5.6. **HBO General basic treatment (nursing)**

- understand information included in prescription of the physician (positioning of patient, breathing modes [mask, hood, other], any additional specific orders [drugs, monitoring, precautions])
- know which information should be given to patient before the first session and before every other session
- be able to give practical information about the treatment to patient (noise, change of pressure and temperature, equilibration of pressure in ears)
- know how-to communicate between staff members
- be able to document the session, including incidence reporting
- be able to perform wound dressing in order to ensure its compatibility with hyperbaric environment
- understand relation between medical history and HBO risks (eg. Diabetes mellitus and hypoglycaemia, cardiac disease and arterial hypertension and/or bradycardia)
- understand differences between different breathing systems (masks/hoods)
- know major acute HBO complications, adverse and side effects (incl. oxygen-induced seizures, gas embolism, pneumothorax, respiratory/cardiac arrest, ear/sinus barotraumas, claustrophobia, vomiting, hypoglycaemia)
- be aware of different options for sedation (psychological, pharmacological and physical)

5.7. **HBO Diagnostic, monitoring and therapeutic devices in chambers**

- understand different options for monitoring modalities (modules-in/monitor-in; modules-in/monitor-out)
- know the limitations of monitoring possibilities (eg. maximum readouts for oxygen partial pressure)
- understand how the hyperbaric environment influences monitored values (eg. humidity and pressure on CO_2 measurement in exhaled gas)
- know how to perform calibrations and zeroing of measurement modules
- know how to control the accuracy of therapeutic devices (eg. monitoring of blood pressure when using automatic pumps or syringes with vasoactive drug)
- be able to transfer intensive care patient into the chamber with all necessary monitoring and therapeutic equipment

5.8. **Risk assessment, incidents monitoring and safety plan in HBO chambers**

- understand definitions of terms (hazard, risk, risk assessment, incident, procedure, etc)
- understand the general structure and methods of risk management
- be able to look for the hazards
- be able to understand the risk assessment report and react accordingly
- be able to assess the risk for hypothetical hyperbaric facility
- be able to prepare the standard operating procedure (SOP)
- be able to prepare the emergency operating procedure (EP)
- be able to recognize incidents and monitor them
- know the risk factors for HBO therapy (pressure, changes of pressure, pressure differential, oxygen content, breathing mixtures, patient clinical condition, personnel health status, prohibited materials, electricity, confined space)
- know the treatment hazards for patients (barotraumas, oxygen toxicity, breathing difficulties, continuation of intensive care inside the chamber, limitation of personnel support inside the chamber)
- know the occupational hazard for personnel (pre-existing health conditions, decompression illness, oxygen toxicity, long term effects)
- be able for fire prevention
- understand fire fighting strategy
- be able to prepare the safety plan for HBO chamber

5.9. **HBO Safety regulations**

- know international and local regulations, guidelines and standards on pressure and medical devices (MDD, PDD, European Code of Good Practice for Hyperbaric Oxygen Therapy, EN14931)
- know international and local standards on safety recommendations

Appendix 4. Scope of diving

The term "working diver" is used for all divers who dive for a reward. This is a legal term that, in addition to working for money, includes those who dive in return for some non-monetary reward. Thus previously unregulated divers, such as some part-time fishermen, are now required to comply with their national diving regulations regardless of their principal employment and this appears to have led to a reduction of incidents.

The "Working diver" is the preferred term because, though the distinction is not essential, it covers all categories of commercial and professional divers. These terms are synonymous but sometimes imply a different working style, viz:

A commercial diver tends to be employed full-time for diving duties, primarily by an offshore, inshore or inland diving company, port or other water-related authority:-

- Offshore diver (oil and gas industry, salvage, wind farms at sea)
- Inshore diver (outfalls, harbours, marine buoys, most fish-farming, etc)
- Inland diver (hydro-electric schemes, bridges, weirs, sewers etc)

A professional diver includes one who may not be working full-time as a diver, but who is employed in another primary role that also requires diving tasks:-

- Military divers for ship husbandry, mine disposal, etc
- Public Service Divers including Coastguard helicopter and Police divers for body recovery and SAR, divers in Fire & Rescue depts, City Hall etc
- Cameramen for underwater photo shoots or filming,
- Diving instructors and guides in the recreational diving industry. This covers all aspects of recreational diving. The diving doctor also needs to know about the special techniques of competitive breath-hold (apnoeic) divers.
- Marine and other scientists (includes some part-time university students)
- Insurance assessors,
- Aquarium and swimming pool attendants (eg for helicopter dunker training)
- Open-sea harvesting (of shellfish etc) and fish-farming

Appendix 5. CME Requirements for Level 2D

All requirements enlisted below under separate numbers must be met with the logical operator AND.

#	REQUIREMENT
1	Renewal at least every 5 years
2	Proof of continuous experience in professional diving related activities*
3	Current certification in advanced life support and defibrillation
4	Successful completion of a refresher course (16 hours, content of courses 1 or 2D) or Attendance at alternative approved events (16 hours)

* Activities that are valid for CME are to be listed in a logbook (analogous to paragraph 6.2. of the standards). This allows in certain limits to compensate for some missing points by adding surplus points from some other actions.

Appendix 6. CME Requirements for Level 2H

All requirements enlisted below under separate numbers must be met with the logical operator AND.

#	REQUIREMENT
1	Renewal at least every 5 years
2	Attendance at at least 5 congresses, conferences or workshops of ECHM, EUBS, SPUMS or UHMS during the last 5 years (alternative events require approval)
3	Current certification in advanced life support and defibrillation
4	Full time work (or the equivalent number of hours part time) during the last 5 years or Successful completion of a 80h hospitation as physician in an approved hyperbaric centre[13]

[13] Requirements for approved hyperbaric centre are listed in the appendix 7.

Appendix 7. Recognition of Level 3 Expert by ECHM

Preamble

The European Committee on Hyperbaric Medicine (ECHM) has the aim of establishing and maintaining standards in Baromedicine (Diving and Hyperbaric Medicine) and towards this aim it has incorporated the European College of Baromedicine (ECB) to become its executive arm in promoting and accrediting the training, clinical and research standards the ECHM has established through its initiatives such as its workshops, consensus conferences and special projects such as the COST B14. The Level 1 accreditation is the natural progression of previously existing and well established courses of Medical Examiner of Divers that have been preparing and certifying doctors for this work for decades and are to be found in one form or another in most EU countries. All doctors who possess such a certification as a Medical Examiner of divers is entitled to accreditation as a Level 1 in accordance to the agreed standards approved by the ECHM and issued on request by the ECB.

The ECB has been accrediting doctors who have completed their training in diving and/or hyperbaric medicine according to the published standards for specialist training in Baromedicine, such standards being one of the main outcomes of the COST B14 European Union initiative, during pre-approved Level 2 courses for some time and, as agreed during the Executive Board meetings of the ECHM, it is now necessary to establish the top level of accreditation, that of the Expert (consultant status).

Aim of this document

This is to establish the additional requirements over and above those required for Level 2 certification and accreditation. The secondary aim is to create a mechanism to take into consideration the training, experience and expertise of those individuals who have been active in the specialty for many years before this system of certification and accreditation was established.

Method

A search and study was made of the practices of a number of EU countries in establishing and registering who is a medical specialist in the various fields of medicine in these countries and what is required in excess to obtaining a specialization in order to be permitted to call oneself and practice as an Expert/Consultant in their country. A search was also made for any EU guidelines, regulations and directives concerning medical specialist status and medical expert/consultant status.

Result of review

All over Europe and in all medical specialities, the Medical Expert or Consultant is an individual who, after completing his formal training as a specialist and having passed the required exam, has practiced his speciality for a sufficient duration and with sufficient exposure to all the important areas of his/her speciality as to be considered by the relevant body in the country to be expert enough to be ultimately responsible for the patients under his care and capable of training new specialists in the field.

The Level 3 is intended for people who are professionally active in the field of diving medicine, hyperbaric medicine or both ("Expert in Diving Medicine", "Expert in Hyperbaric Medicine" or "Expert in Baromedicine"). It is understood that there can be no course that can prepare the candidate for the Level 3 status and the candidate must prove that he/she has acquired expert knowledge, skills and experience in this field.

The already established EU standard that all European or National Medical Specialist Accreditation Committees or Boards are obliged to use is that, following the formal theoretical and practical training, the candidate must work full time in the field for 4-6 years, depending on the country and the speciality, and in the full width of the speciality before becoming eligible for registration as a specialist.

If one looks as the Level 2 as the accreditation given to someone who has had the appropriate academic and practical training to reach that level, then the next level up, according to EU requirements, is someone who has practiced in the speciality full time for a sufficient number of years at an approved facility and has been entered in the appropriate National Specialist Register as an accredited specialist. Following that registration most specialists must then carry out a further minimum of 2 years work at specialist level before becoming eligible to apply for an Expert/Consultant position at a health institution in the country.

Procedure

It is recommended that the ECHM will follow closely the procedure the EU has already approved and already put into practice by other specialisations in Europe[14]. The steps to follow are:

1) Candidate has completed the course and practice for Level 2. He will apply for accreditation with the ECB and if everything is in order will be issued the diploma of Level 2 (or 2D or 2H if only qualified in one area of baromedicine).
2) A level 2 physician who has worked full time (or the equivalent number of hours part time) for at least 5 years with an approved Hyperbaric Facility or Diving Medicine Facility (see Table 4). The candidate must be supervised by an ECB approved Expert in Baromedicine (or Expert in Diving Medicine or Hyperbaric Medicine, respectively).

[14] The EU stops at specialist accreditation and leaves to the individual countries to establish what a specialist needs to accomplish to reach Expert/Consultant status. Most countries expect a specialist to work full time in the field for a minimum of 2 years (some even 5 years) or obtain a higher degree such as a PhD before granting the specialist Expert/Consultant status.

Table 4. Requirements for approval of hyperbaric or diving medicine facility.

#	REQUIREMENT
1	Part of a hospital, university, military or civilian diving / hyperbaric medicine centre
2	Having at least 1 full time ECB approved Level 3 Baromedicine Expert
3	Having capability to treat all clinical indications according to the ECHM list of indications (in hyperbaric or diving medicine, respectively) in all patients, including those which needs intensive care
4	Having at least one multiplace chamber
5	Working according to the European Code of Good Practice for Hyperbaric Oxygen Therapy (ECGP for HBOT)

3) The ECHM requirements to be fulfilled initially by candidate are enlisted in Table 5.

Table 5. Requirements for candidate.

#	REQUIREMENT
1	Diploma 2D or Diploma 2H or both, respectively
2	10 years[15] fulltime work as a diving physician in an approved commercial or military diving company or physician at an approved hyperbaric centre, respectively
3	Recognised as a Specialist in his/her own Country or registered as a Specialist in an EU Country or possessing a PhD based on a thesis in Baromedicine
4	Participation in approved educational activity in diving medicine, hyperbaric medicine or both, respectively. This includes at least giving lectures on at least 2 courses (on level 2D or 2H, respectively) accredited by the ECB.
5	Participation in the research in diving medicine, hyperbaric medicine or both, respectively. This includes at least being co-author of at least 2 publications in peer review journals or chapters in published books.
6	Expert References, which means positive written opinions given by two independent experts in Baromedicine recognised as such by the ECHM EB[16]

4) The Diploma of Level 3 Expert is given by the ECB after review of the application by the ECB Accreditation Board. An unsuccessful candidate has the right to appeal the decision of the Accreditation Board with the ECHM who will appoint 3 independent experts to review the case and if their report favours the candidate, the ECHM will request the ECB to review the case. The final decision of the ECHM cannot be further appealed.

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[15] If there is a PhD thesis, the time required in point 2 can be shortened from 10 years as decided by the accreditation body.

[16] "Independent Expert" means Level 3 experts working in the HBO centres or diving companies that have no connection with the facility the applicant is working with.

5) Approved Level 3 status is active for 3 years.
6) Renewal of active status of the Level 3 diploma is based on proof of continuous clinical, teaching or research activity in his expertise field. This includes at least 3 events (from the list in the Table 6) conducted in the last 3 years.

Table 6. Requirements for renewal.

#	REQUIREMENT
1	Participation in the international congresses, conferences, workshops or other scientific meetings organized in cooperation with or approved by of the ECHM, EUBS, ICHM, SPUMS, UHMS. Seminars and meetings organised by other scientific bodies or academic institution may be considered by the ECB.
2	Giving lectures on level 2D or 2H courses accredited by the ECB.
3	Being co-author of at least one publication in a peer reviewed journal or a chapter in published books.[17]
4	Other activity in the field of diving or hyperbaric medicine. This includes for example active participation in the international bodies, leadership or active participation in international projects, leadership of hyperbaric centre.

Grandfathering

It is established practice in the EU with regard to individuals who are already working at Specialist and Expert/Consultant level in their country when new Accreditation and Specialist Training systems are formally set up for the first time to enrol these individuals through a Grandfathering Scheme which recognises their years of experience as full time recognised practitioners in the field and enrol them into the respective register.

The standard number of years to be registered as a Medical Specialist with the Grandfathering concession was established by the EU as 8 years full time practice in the full breath of the speciality at an appropriate clinical facility (therefore, in our case, almost double the clinical experience needed to reach specialist status if successfully concluding a Level 2 course).

As for Grandfathering for Level 3, since there are many who are truly knowledgeable and experienced but have no formal academic qualification in Baromedicine, the ECHM decides to grant this to individuals who are known leaders in their field in each country, have contributed to the science and education of Baromedicine and have a further 8 years full time experience in the field (so 16 years in all) and who are recommended by the ECHM EB to be given Level 3 Expert status.

[17] ECB Accreditation Board may consider postponing this requirement if the circumstances are justified.

Fees

The ECHM also needs to decide on fees due for such accreditation as well as an application/processing fee to cover administrative costs.

References

The English language versions of EU directives and documents arising from them were used and these were mainly sourced from these sites:

http://admin.uems.net/uploadedfiles/906.pdf

http://admin.uems.net/uploadedfiles/174.pdf

http://www.commonlii.org/mt/legis/consol_act/hcpa236.txt/cgi-bin/download.cgi/download/mt/legis/consol_act/hcpa236.pdf

http://admin.uems.net/uploadedfiles/175.pdf

http://admin.uems.net/uploadedfiles/35.pdf

http://www.cme-european.org/PDF/ESAB_Position_Paper_November_2005.pdf

https://ehealth.gov.mt/download.aspx?id=1000

http://www.sahha.gov.mt/showdoc.aspx?id=76&filesource=4&file=ophthalmology_trainingprog.pdf

http://www.sahha.gov.mt/showdoc.aspx?id=76&filesource=4&file=ApplicationForm_FinalVersion_Medical_.pdf