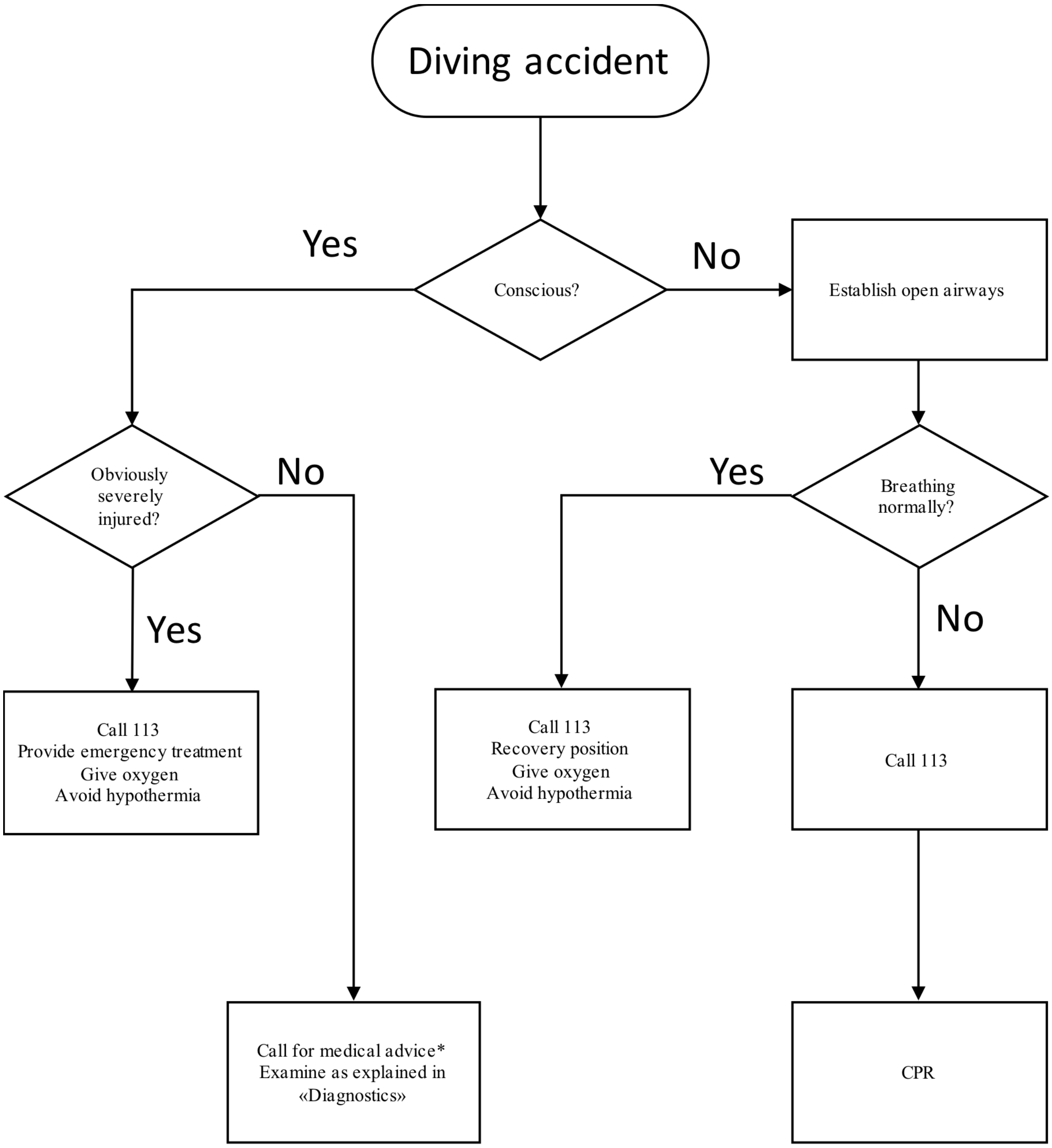
Norwegian Diving- and Treatment Tables

Emergency Action Plan



*Depending on situation: Emergency medical dispatch service (113), Out-patient emergency ward (116117) or the duty diving physician Haukeland University Hospital (55361700)

Jan Risberg • Andreas Møllerløkken • Olav Eftedal

Norwegian Diving- and Treatment Tables

Tables and guidelines for surface orientated diving on air and nitrox. Tables and guidelines for treatment of decompression illness.

This is an authorized translation of the fourth edition of
'Norske dykke- og behandlingstabeller'

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Hans Petter Roverud, Jan Risberg, Bob Gardiner
Fourth edition: English translation by Jan Risberg

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Preface

This is the fourth edition of the Norwegian Diving- and Treatment Tables. This book contains tables for diving on air or nitrox, as well as therapeutic recompression procedures for decompression illness and other ailments requiring hyperbaric treatment.

The present (fourth) edition has been significantly revised. The decompression tables for dives not considered exceptional (i.e. not identified with asterisks) are mainly unchanged from the third edition. However the exceptional dives and $SurDO_2$ dives have been revised with more conservative decompression obligations (shorter bottom times and/or extension of decompression times). The procedures for repeated dives are unchanged, but the schedules slightly adjusted. Additionally, we have introduced a procedure for multilevel diving.

This publication aims to further increase the understanding of safe diving procedures. Hence, we emphasize the correct application of diving tables to limit the risk of decompression illness. We also focus on the correct procedures whenever an incident takes place. This publication targets all personnel involved in diving operations and a thorough knowledge of diving medicine and diving physiology is no prerequisite.

With regard to diving medicine, there are divergent views on several issues. Most of the controversy stems from the lack of documented research and/or from inconclusive results. The reader should keep this in mind.

This edition has been edited by two new authors: Olav Eftedal and Andreas Møllerløkken. Cdr SG (ret) Arne-Johan Arntzen has decided to withdraw from further editorial work due to age and workload. Previous head of submarine and diving medicine Svein Edsvik passed away in 2015. Arntzen and Eidsvik have been editors of the previous editions of these tables. Their contribution to standardized decompression and treatment procedures will forever be recognized.

Bergen, 15.1. 2017

Jan Risberg Andreas Møllerløkken Olav Eftedal

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Introduction

1. **Any Diving Table Will Entail a Compromise** between maximizing bottom time versus decompression time on the one hand and minimizing the risk of decompression illness (DCI) on the other. During the latest years we have seen an increased focus on lowering the risk of contracting DCI. While these tables do not offer a novel approach to the problem they represent a modified approach being based on the best of well-tested tables and procedures. Any of these modifications have been based on real-life experience, namely a great number of various profiles that have been logged by Norwegian diving companies, using a variety of equipment.

2. **The "Norwegian" Decompression Tables** have remained essentially unchanged since they were issued for the first time in 1980 (NUI-report 30-80). The tables were printed as an independent publication in 1986 and later revised in 1991, 2001 and 2008. The air decompression table (staged in-water decompression with air as a breathing gas) is based on Royal Navy's Table 11 (1979 edition), though modified with a slower ascent rate and a different procedure for repetitive dives. Bottom times contracting decompression time exceeding approximately 35 min are identified with asterisk (dives not recommend to be planned for).

3. **The Surface Decompression Table Using Oxygen** (SurDO_2) is based on the US Navy Diving Manual Rev 7 (2016 edition). There are certain national adjustments, e.g. units of diving depth in metres rather than feet and the Norwegian procedures do not allow repeated SurDO_2 dives.

4. **The Use of Oxygen-enriched Air** (nitrox), including its optional use with surface decompression, is fairly uncommon in Norwegian commercial diving. Used properly, nitrox may improve safety as well as cost effectiveness.

5. **The Responsibility of the Dive Supervisor.** Care should be taken when reading the decompression tables. Tables may appear to provide the correct decompression for any exposure, solely based on depth and bottom time. Other factors such as work load and diver's individual predisposition for DCS should affect decompression obligation. We try to bring these and other matters to the attention of the reader.

6. **Decompression Illness and Long-term Health Effects.** Recent research confirms that neurological DCI is more common than previously thought. Additionally, the incidence and extent of long-term health effects of DCI seems more extensive than previously believed. It is thus important to use diving procedures that minimize the risk of DCI.

7. **Table Safety.** A given dive table's safety is commonly presented as expected DCI incidence. To ascertain the true incidence of DCI, a large number of properly logged dives are required. In spite of this, the end results may be equivocal. Several tables have been subject to testing (among these US Navy (USN), French and Norwegian tables), but there is presently no substantial advice to support superior safety performance of one table compared to the others. Measurement of venous gas embolism ("silent bubbles") are frequently accepted as an outcome measure when testing new tables. Decompression tables may be compared on the basis of extent of venous gas embolism, but extent of intravascular bubbles is not a sensitive measure for health effects. Diving may cause long term health effects on e.g. lungs, the skeleton and nervous system, but these health effects develop so slowly that they are difficult to associate with the use of a certain decompression table. It is extensively documented that DCI is a risk factor for later development of long term health effects on the nervous system. In the absence of better outcome measure, the incidence of DCI is commonly accepted as a performance indicator of a decompression table.

8. **The 'Norwegian Tables'** have been used by Norwegian Society of Underwater Contractors. Diving contractors have logged diving activity (hours of diving) and DCI incidence since 1994. Through the decade of 1993–2003 ~ 220,000 hours were logged and the DCI incidence reached ~ 0.05 ‰ per hour; i.e. one case of DCI per 20,000 hours. The Norwegian Oil Directorate published a report in 1994 on standard decompression tables for surface oriented diving. Six institutions were questioned concerning their experience using the Norwegian standard tables. The diving on the Kalstø project had a particular high incidence (9259 dives, DCI incidence 0.18%). The other dives (52353) had a DCI incidence of 0.04%. Studies have reported that some divers experience symptoms after decompression not being reported to physicians ("unreported DCI"). Treatment of DCI using the company's recompression chamber will add to this. Still, we assume that the number of such unreported treatments are small.

9. **Shields and Coworkers** published in 1989 a report analysing the incidence of DCS after surface oriented dives on the UK continental shelf. It is worth mentioning that the report analyse approximately 130 000 dives with other decompression procedures than those recommended by the Norwegian tables. The incidence of DCS was 0.26%, but the most important result in the report was the description of risk associated with dives with high inert gas load. Dives with high inert gas load (as indicated by their "PRT" –i.e. the product of pressure and square root of time) had significantly higher risk of DCS than dives with less inert gas load. Shields and co-workers recommended a PRT=25 to border the high- and low risk dives. UK authorities (HSE) has established PRT 30 as a threshold for surface oriented dives without the use of TUP (Transfer Under Pressure, pressurized diving bells). The UK bottom time limitations are referred in the section of "Prevention of decompression illness" in this publication.

10. **Traditional Models for Decompression** (decompression algorithms) compute gas flow in and out of mathematical "tissues" (compartments) and mandate decompression to restrict the supersaturation of these compartments. Though there are multiple algorithms for calculation of gas transfer, the so called deterministic models have a common conception that dives are either categorized as "safe" or "unsafe" depending on whether the maximum permitted gas tension has been exceeded.

11. **New Statistical Models** (probabilistic models) have been used by the US Navy in Rev 6 and 7 of the US Navy Diving Manual. Even though the algorithm for calculation of gas flow and the concept of maximum permitted gas tension remains unchanged, the statistical model allows estimation of the probability of DCS depending on the extent of supersaturation. This allows construction of tables that is a compromise between efficacy and risk. Rev 7 of the US Navy Diving Manual has a typical estimated risk of DCS between 2% and 6% depending on depth, bottom time and decompression mode.

12. In our work with the 4th edition of the Norwegian diving tables we have estimated the risk of DCS using the previous (3rd) edition of the tables. The analyses show that DCS risk typically range 2% to 5% for "non-indexed" (non-exceptional) dives. The DCS risk was in the same order as compared to US Navy Diving Manual Rev 7. The experience using the Norwegian diving tables for non-exceptional air staged decompression dives is generally good (see earlier discussion in this chapter) and the new (Rev 7) US Navy Diving manual advice significantly longer decompression time without demonstrating a similar significant improvement in safety compared to the Norwegian tables. By this reason, the changes in decompression obligation is small comparing 3rd and 4th edition of the Norwegian tables with respect to non-exceptional staged decompression dives.

13 **The Risk for DCS was High** using the previous US Navy procedures for surface decompression, exceeding 8% for the longest dives. Norwegian procedures for $SurDO_2$ are different from the USN and we do not know exactly which risk for DCS that could be expected using the Norwegian $SurDO_2$ procedures. Wayne Gerth (US Navy Experimental Diving Unit, personal communication 2016) has estimated the risk of DCS for various combinations of bottom times in the 24-36m depth range of the 3rd edition of the Norwegian decompression tables. The DCS estimates, calculated by means of the USN probabilistic model, typically ranges 7-8%. Experience using Norwegian $SurDO_2$ procedures on larger Norwegian projects, the report of Shields and the risk assessment of the USN suggest that $SurDO_2$ procedures could be associated with an increased DCS risk. Due to this we have decided to implement USN procedures for $SurDO_2$ in this table edition as these procedures are expected to reduce the DCS risk significantly.

14. **The Procedures for Repeated Dives**, diving at altitude and flying after diving are unchanged from the previous edition, but the exact times are adjusted in agreement with recommendation from US Navy Diving Manual Rev 7.

15. If the procedures in this table are used, the risk for DCS is expected not to exceed 5% for non-exceptional dives. Exceptional dives (indexed by *) should not be planned for, but if the situation requires their use (e.g. exceeded bottom time by a mistake or an emergency situation) the DCS risk will range between 5% and 6%.

16. **Multilevel Diving.** In this revision we introduce a procedure for multilevel diving similar to what has been published previously in Canadian tables. Multilevel-dives may be planned as a series of repetitive dives. There is very little data available regarding the safety performance of dives planned according to such procedures. Until further data is available related to such multilevel diving, we strongly recommend to respect the restrictions advised by us.

17. **Other Major Changes.** We will mention that maximum recommended pO_2 is 1.5 Bar (relevant for Nitrox diving). We have advised for a procedure for a formal assessment of risk factors for DCS and how decompression should be adjusted depending on the presence of multiple risk factors. We dissuade against the use of air as breathing gas deeper than 50 metre. The standard air decompression table and $SurDO_2$ table have been given a layout that makes it easier to trace maximum allowed bottom times for petroleum related diving limited by UK bottom time regulations.

18. **Formal status – translations and revisions.** These tables are published in electronic and printed versions. They are additionally published in English language. The original version is in Norwegian, and in the case of inconsistencies between Norwegian and foreign versions, the Norwegian version should be given precedence. Changes will be published on www.dykketabeller.no. Later revisions of these tables will be indicated by letters (A,B,C etc). Minor changes of a current revision will be identified by numbers (A1, A2 etc). Such minor changes will *not* be formally committing and will not be printed, however they will be available for download at the website. A log of such changes will not be printed but may be downloaded from the website. The authors recommend that readers of printed tables manually correct the printed text when changes are published on the website.

19. **Reccomendation for Use.** We recommend that the Norwegian decompression tables should be used because they by experience have given an acceptable protection against DCS. The present edition is expected to contribute further to safe diving. It is important to have standardized decompression procedures to avoid the risk for errors when teams of divers are put together.

Standard Air Decompression Table

1. **Table Depths**, that is, the depths listed in the tables, provide the maximum depth for a given profile. Thus, a dive to 30 m uses the 30 m entry. A dive to 30.5 m uses the 33 m entry (next higher) and so on.

2. Whenever the depth is determined by actual measurement of the water depth, the deepest point being measured should be used for table depth. Preferably, depth should be determined pneumatically or electronically, in which case the measurement should be read at the diver's lower chest level. Regarding units and accuracy, 1 bar translates to a depth of 10 m and there is no need to differentiate between sea water and freshwater.

3. **Bottom Time** is defined as the time from the diver leaving the surface (descent) until the start of the ascent. A given table time means the maximum bottom time allowed for a given decompression schedule at a given depth. To avoid exceeding the table time it is a good idea to prepare the diver for ascent shortly before the maximum time is up. By doing so he will avoid the need to switch to the next longer schedule.

4. Based on the actual bottom time and depth the table is consulted to determine the proper ascent, decompression stops included. Note that except for the first/deepest stop, the stop time at each mandatory stop should include the proper ascent time to reach the stop depth. The diver should position himself with the lower part of his chest at the stop depth.

5. PROBLEM: You have made a dive to 19 m for 64 min. Which table entry should be chosen and what is the proper ascent?
   SOLUTION: The correct table entry is 21 m for 70 min. The prescribed decompression is 5 min at 6 m and 10 min at 3 m. This means that 5 min should elapse from arrival at the 6 m stop until he leaves it. Then a further 10 min should elapse from leaving the 6 m stop until leaving the 3 m stop and heading for the surface.

6. **The Ascent Rate** is 10 m/min. This rate of ascent applies to surface ascents (no-stop dives) as well as ascents from the bottom to the first decompression stop. The same rate shall be applied for the ascent between the shallower stops. A no-stop (or no-decompression) dive is defined as a dive that does not require any decompression stops. The time for ascent to the first decompression stop should not be included in the decompression time listed for that stop in the table. Whenever the actual ascent rate has been too slow one should definitely not increase the ascent rate to 'catch up' during final ascent. The time from one stop to the next should be about one minute. When the time at 3 m is up the mandatory decompression has been completed and the diver ascends to the surface. Note that a proper ascent rate constitutes an integral part of a proper decompression schedule. A careless, rapid ascent may cause the same kind of problems as omitted decompression time at mandatory stops. If the time for ascent to the first stop is delayed by more than one minute relative to the prescribed time, the extra time should be added to the bottom time and decompression be adjusted according to this longer bottom time.

7. **The Total Decompression Time** as tabulated in the tables list the time to be spent at the staged decompression stops, but do not include ascent time from bottom depth to deepest decompression stop nor ascent time from shallowest water stop to surface. "Total decompression time" is not listed for no-decompression dives.

8. **A Single Dive**, or a 'Non Repetitive Dive' as opposed to a 'Repetitive Dive', is defined as a dive that starts when all excessive gas accumulated during the previous dive has off-gassed. How long time this will take depends on the depth and bottom time of the previous dive. All excessive gas is expected to be eliminated after 16 hours and consecutive dives are considered "Single Dives".

9. **Repetitive Group.** When the diver returns to the surface after finishing a dive, he will still have an excess of nitrogen in the body. A letter for each combination of time/depth in the column "Repetitive group" indicate the extent of this nitrogen excess. It is identified with the letters A through Z (actually A through O in addition to Z) where A indicate the smallest and Z the highest nitrogen load.

10. **A Repetitive Dive** is a dive starting before all excessive gas from the previous dive has off-gassed. In such cases the repetitive dive will carry a penalty, meaning that the exposure will be calculated by adding the penalty (the Residual Nitrogen Time) from the previous dive to the actual bottom time.

11. **Repetitive Group Adjusted for Surface Interval.** The longer the diver stays on the surface after the dive before carrying out a repetitive dive, the less is his residual nitrogen. To find the adjusted Repetitive Group, use the **Residual Nitrogen Timetable for Repetitive Air Dives.** The letters from A to Z sloping diagonally across the table are the Repetitive Groups after the dive. To the right of every Repetitive Group, times (in hours and minutes) since surfacing from the last dive have been listed. On the bottom line, vertically under the time period spent

on the surface, is the adjusted repetitive dive group for that surface interval. The table shows how long you have to wait before a repetitive dive may take place without a penalty to the bottom time.

12. **The Residual Nitrogen Penalty** (The Residual Nitrogen Time) will be determined by the planned depth of the next dive and the amount of excess nitrogen that the diver holds from the previous dive. The higher the amount of nitrogen still being dissolved in the diver's tissues, the higher the penalty. The Residual Nitrogen Time is actually a measure how long it would take to acquire the actual amount of nitrogen at the second dive's planned depth. Hence, the Residual Nitrogen Time will be less the deeper one dives on the second dive since it would take less time to acquire the actual nitrogen load at a greater depth. The 60m table does not provide data on residual nitrogen penalty, accordingly a dive to 60m cannot be a repetitive dive.

13. **Dives to Depths not Exceeding 6 Metres.** There may be planned an unrestricted number of dives to depths not exceeding 6 m. There are neither any restrictions on bottom times except that stipulated by regulations related to the petroleum activities. When such dives are planned as repetitive dives, the Repetitive Group Designator should be calculated conventionally. For those cases where a diver holds a Repetitive Group Designator exceeding "K" no reduction should take place during the dive, but should be corrected for surface interval only.

14. PROBLEM: You dive to 23 m for 28 min. After having spent two hours on the surface you conduct a second dive, this time to a depth of 19 m. Which adjusted Repetitive Group Designator applies and how much time can you spend at 19 m without incurring a need for a decompression stop?
    SOLUTION: The first dive gives a table depth of 24 m and a table time of 30 min (next higher in both cases) which earns Repetitive Group 'H'. To find the adjusted letter group, pick 'H' on the diagonal line and run across the time groups until you reach the one that applies to a surface interval of two hours. It falls within the 1:41 – 2:40 entry. Moving down from this entry you find the letter 'F'. This is the adjusted letter group for a 2 hours surface interval. Now, the next problem will be to select the table depth of the second dive. Since 19 m isn't listed the correct choice is a table depth of 21 m. To the bottom of the 21 m table you'll find a row listing the Residual Nitrogen Time for various Repetitive Group Designators. An 'F' translates to a 30 min penalty for a dive to 21 m. Since the maximum no-stop time is 45 min at 21 m a 30 min Residual Nitrogen Time means that we have 15 min left. Thus, the maximum no-decompression bottom time for the second dive is 15 min. Longer bottom times will require decompression stops.

15. **A Surface Interval of Less than 10 Minutes.** In this case the bottom time is taken as running continuously without regard for the surface interval. However, this is not recommended if the initial part of the dive would have required decompression stops, or come close to requiring decompression stops.

16. **Strenuous Dives.** Some dives are more strenuous that others or are more predisposing for DCS. This is covered more thoroughly in the chapter 'Prevention of Decompression Illness'. Repetitive dives and diving for several consecutive days has been shown to increase risk, especially when the dives are strenuous. This holds true even if the dives are completed according to the decompression table. This warrants a definition of what we consider 'strenuous'. Common sense as well as practical experience indicates that these factors should qualify a dive as 'strenuous' in relation to repetitive and consecutive days diving:
   - Dives deeper than 30 m
   - Multilevel-dives
   - Dives earning a decompression penalty of more than 15 min.
   - Physically challenging dives
   - Being uncomfortably cold while decompressing

17. **Repetitive Dives** should normally be limited to one. However, two repetitive dives are acceptable when neither of them falls within the strenuous category. In any event, a dive can always be followed by another dive to a maximum depth of 9 m (or an equivalent air depth of 9 m when using nitrox).

18. **Diving Several Consecutive Days.** There should be no more than three consecutive days of diving if one or more of the dives have been strenuous. Conversely, when no dives have been strenuous (according to factors listed above) it is not considered necessary to have a non-diving day. In any event, a dive can always be made to a maximum depth of 9 m, or an equivalent air depth of 9 m when using nitrox. This is technically considered as a non-diving day.

19. **Deep Chamber Dives.** From experience we know that divers are prone to developing mild skin symptoms ('skin bends') during deep, dry chamber exposures. Mostly, these exposures have been carried out to test the divers' susceptibility to nitrogen narcosis. Regrettably, the standard air in-water decompression table has proven less safe for these exposures. See the chapter Deep Chamber Dives.

20. **Other Restrictions.** The tables mark the longest exposures with an asterisk (*). This is done to indicate that these exposures should be avoided. Such exceptional dives will either require long decompression time in water (exceeding 35 min) or an increased risk of DCS (ranging 5% to 6%). For oil and gas related diving (diving regulated by the Norwegian petroleum regulations) it may be required to restrict bottom times according to UK regulations. Bottom times not to be planned for in petroleum related diving are listed below the bold horizontal line in the tables. Air should not be used as breathing gas in dives exceeding 50 metres. Due to this, the profiles for depths ranging 54 through 60m are identified with asterisk. Please note the 370 min bottom time limitation on the 9 m table (introduced in the 4th edition of these tables).

21. **Multi-level Dives.** According to basic guidance for the use of decompression tables, the depth of a dive is determined by the greatest depth reached. The multi-level approach, on the other hand, considers the inert gas uptake at various levels. This will allow a considerably longer total bottom time, provided that the deeper levels come first. These tables may be used for planning of multilevel-dives as explained in the appropriate chapter.

Diving at Altitudes above 250 m

1. **The Ambient Pressure at Sea Level** (standard barometric pressure) is one atmosphere. This pressure translates to 760 mm of mercury (mm Hg), 10.332 m of fresh water and 1013.25 hPa. For all practical purposes we can use the approximation 1 bar = 1000 hPa = 10 m of water, whether freshwater or sea water.

2. As we ascend above sea level the ambient pressure drops. Close to sea level pressure drop is about 1 hPa per 8.6 m increase in altitude. However, the higher up we go the less the pressure drops with a further increase in altitude. The summit of Mount Everest is at 8848 m above sea level (m asl.). At this altitude the ambient pressure is 314 hPa.

3. Meteorological changes affect ambient pressure, i.e. high or low pressure weather systems. A pressure of 935.5 hPa is the lowest atmospheric pressure recorded at sea level in Norway. This corresponds to the standard barometric pressure at a height of 670 m asl.

4. **Diving at Altitude.** The ratio between the pressure at a given depth versus the surface pressure will be larger when diving in a mountain lake compared to sea diving. This will affect decompression obligation. There are two basic approaches to this problem, namely to use corrective factors for standard tables or to switch to tables that have been recalculated for a specific altitude.

5. **Cross correction.** A simple, widely used approach is to calculate the 'corrected depth' based on the ratio between the absolute ambient pressure at depth and the surface atmospheric pressure. Since this procedure was worked out by E. R. Cross it is commonly being referred to as the 'Cross correction'. Corrected depth (D_c) can be calculated according to this equation:

$$D_c = \frac{\text{Actual depth at dive site} \times \text{Atmospheric pressure at sea level}}{\text{Atmosperic pressure at dive site}}$$

6. While it is impractical to measure the current atmospheric pressure at a dive site it is usually no problem to identify elevation by consulting a map of the area. Then one can choose the correct table applicable to this elevation. The table 'Correction for Dive Site Altitude' provides the table depth to be used for a given diving depth.

7. **Altitudes Lower than 250 m Above Sea Level.** There is no conversion table for altitudes that do not exceed 250 m asl. Further, there is no need to consider normal barometric variations, even though a low-pressure system may actually correspond to a few hundred metres increase in altitude.

8. **Altitude Acclimatisation.** When a diver arrives at a high altitude site his tissues will hold an excess of dissolved nitrogen (super saturation). This residual nitrogen load is similar to the one acquired after a repetitive dive. Depending on the altitude, this nitrogen surplus will call for a decompression obligation corresponding to an extension to the actual bottom time, similar to the situation for a repetitive dive. During the stay at altitude, this residual nitrogen load will be reduced as presented in the residual nitrogen timetable. As shown in The Residual Nitrogen Time Table for Repetitive Dive, there is no penalty if the diver has stayed in the altitude for at least 8 hours (actually 7h 10min).

9. PROBLEM: A diver is acclimatized to an altitude of 400 m asl. Then he moves up to a dive site at 1,300 m asl. to carry out a dive to a depth of 18 m. Which table will you use to determine Repetitive Group Designator and corrected depth?
SOLUTION: The dive site at 1,300 m asl. falls within the 1250 – 1500 m asl. entry. The depth entry that applies to 18 m is 20 m (equal or next higher). By following the 20 m row to right you find the corrected depth, namely 24 m.

10. Provided the diver had ascended directly from sea level his Repetitive Group Designator would have been 'D' as per the 1250-1500 m asl. column. Since he has only ascended 900 m we can safely use the 750 – 1000 m asl. entry which earns him a 'B'. This translates to a 10 min penalty (addition to the actual bottom time) at a table depth of 24 m.

11. **Reduction of Repetitive Group Designator.** Similar to sea level condition, the body will eliminate nitrogen-excess when you stay at altitude. The Repetitive Group Designator will therefore be reduced the longer you remain at altitude. If you hold excessive nitrogen (a Repetitive Group Designator) from a previous dive, this should be added to the one attributed to the one mandated by lack of acclimatisation.

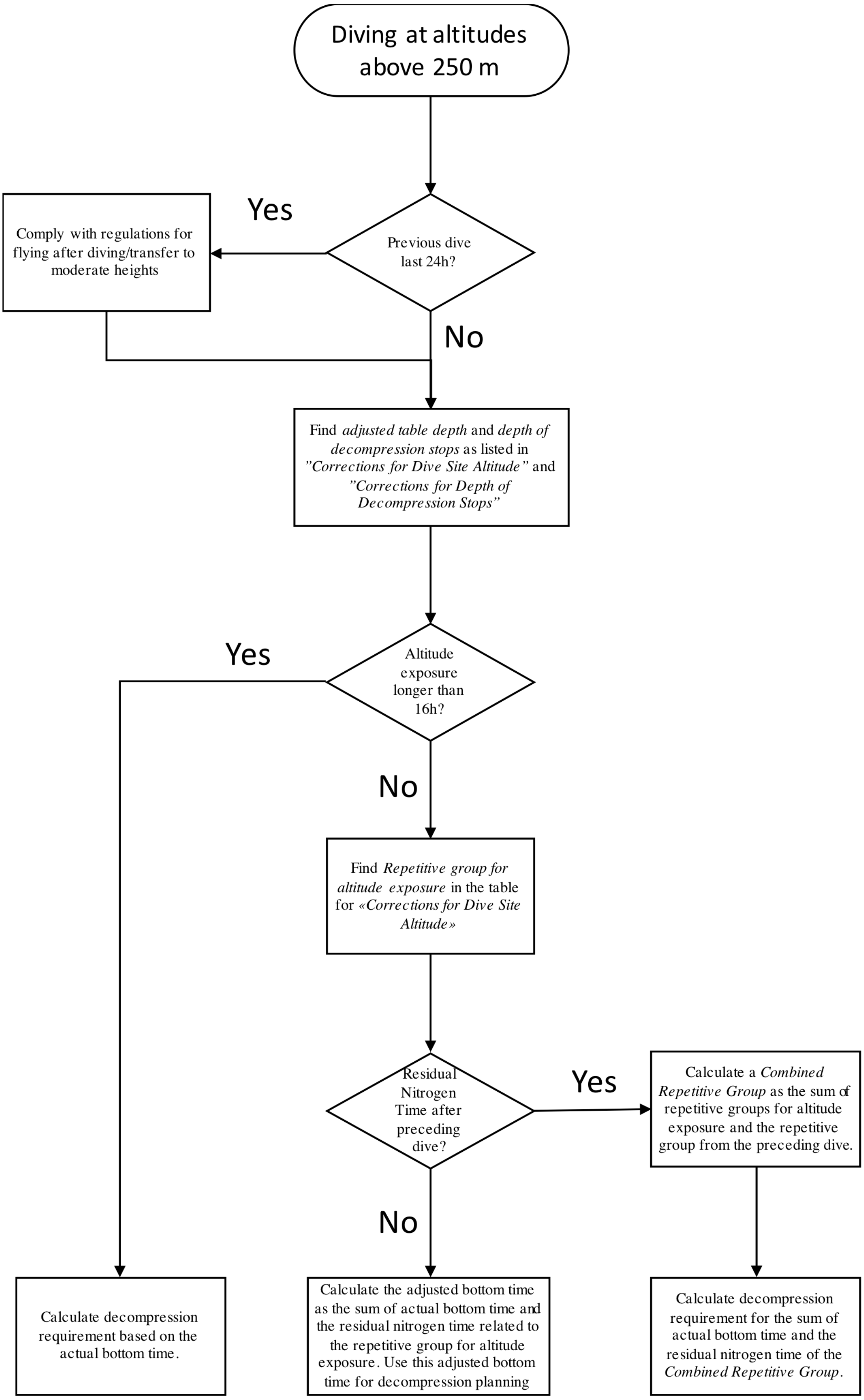
12. **Calculating the Residual Nitrogen Time** for repetitive dives at altitude when the diver is not acclimatized. The residual nitrogen time for a dive at altitude which takes place before the diver is acclimatized and while the diver still carries a Repetitive Group from the previous dive is done by adding the Repetitive Groups. Start by converting the Repetitive Group Designators to numbers. The Repetitive Group A is given the number 1, Repetitive Group B is number 2 aso. Following this, the Repetitive Groups may be added. A diver holding a Repetitive Group of "B" (2) after the previous dive and Repetitive Group "D" (4) due to lack of acclimatization will carry a residual nitrogen time as prescribed by letter "F". The reason is that the Repetitive Group from the previous dive and the Repetitive Group associated with ascent to altitude will summarize to 6, i.e. the 6th letter (F).

13. PROBLEM: A diver drives from Bergen to Finse (1222 m asl) and wants to dive without considering a penalty to bottom time. He holds a Repetitive Group Designator of "B" from his last dive at time of arrival at Finse. How long will he have to wait before diving?
    SOLUTION: The altitude (1222 m asl.) is within the column for 1000-1250 and address a Repetitive Group Designator of "C" when arriving at Finse. His Repetitive Group Designator from last dive ("B") should be added as two extra letters, calling for diving compliance with an "E". In agreement with the Residual Nitrogen Timetable for Repetitive Air Dives he has to wait at least 6:21 before he can dive without considering penalty for nitrogen excess from sea level exposure and his last dive.

14. **Compliance With Regulations for Flying after Diving. If the diver has a Repetitive** Group Designator after the previous dive, the rules for flying after diving should be complied with.

15. **Decompression Stop Depths.** Theoretically, the most correct altitude conversion would involve a slight upward shift of the decompression stop depths. However, for all practical purposes the correctly adjusted stop depths would be insignificantly different from the standard stop depths and there's no need to adjust depths by a few centimetres. Hence, the standard stop depths will be used whenever the corrected stop depth differs by less than one metre. Neither theoretical nor practical concerns indicate that there is any need to observe these minor adjustments of stop depths.

Flowchart for diving at altitudes above 250 m



Flying after Diving

1. Extensive practical experience confirms that flying after diving increases the DCS risk. The problem is not flying per se, but the additional decompression caused by a reduced cabin pressure. International regulations allow the cabin pressure in commercial aircrafts to drop as low as the ambient pressure at 2,500 m (8,000 ft). Our recommendations are based on this cabin pressure. The same kind of problem may arise whenever a diver is exposed to lower ambient pressure shortly after a dive, for instance by driving to mountain areas.

2. There are many factors to consider. For this reason it is hard to provide safe and simple guidelines without being overly strict. Acknowledged organizations such as DAN, PADI, USN and DMAC all have their own guidelines as to flying after diving but they are hardly in agreement.

3. Generally, the deeper and/or longer the dive, the lower the cabin pressure and the shorter the time since the dive was completed the higher the DCS risk. We can easily control and keep track of the time from completing the dive until we board a plane. We may also safely assume that the cabin pressure will stay above the mandatory minimum. However, the hard-to-assess aspect is the exact decompression stress from the previous dive(s). We know that repetitive dives, strenuous dives and diving for several days will increase the risk of bubble formation. These bubbles may persist and increase the risk of DCS during a subsequent flight.

4. **Flying after recreational diving.** Even though the risk of suffering from DCS after flying is small, the medical and financial consequences may be substantial. Thus, we advise recreational divers to avoid diving on the last day before flying, especially after a series of repetitive dives or diving for several days consecutively. This would typically apply to the standard 'diving holidays'.

5. **Flying after occupational diving.** When diving according to the standard air table or the surface decompression table in this publication, which is the normal practice for occupational divers, the 'Time before flying after diving' tables in paragraph 8 on the next page should be used. These numbers are based on new recommendations provided by the US Navy.

6. **Flying under extreme conditions.** Note that we do not intend to cover flights in an unpressurized aircraft above 2,500 m asl. (8,000 ft asl.). If such flights are being planned we recommend that you contact baromedical expertise and obtain their advice.

7. **Flying after DCI.** Whenever a diver has suffered DCI, even when successfully treated and fully resolved, extra time before flying may be warranted. In these cases, baromedical advice should be sought before flying. You may expect widely different guidelines in various countries. Actually, anything from one to 30 days prohibition of flying may be advised!

8. **Time before flying after diving**

Repetitive group after the dive	Minimum time from end of last dive to flying
A to C	0 hours
D	2 hours
E	5 hours
F	7 hours
G	9 hours
H	11 hours
I	13 hours
J	14 hours
K	16 hours
L	17 hours
M	18 hours
N	19 hours
O	20 hours
Z	21 hours

Dives not identified by a Repetitive Group Designator should incur a minimum of 24 hours without flying.

9. **Transfer to moderate heights** (e.g. mountain passes) will impose a certain risk of DCS if it takes place to shortly after a dive**.** The rules for flying after diving should be respected for all exposures to heights exceeding 1250 m asl. For exposures to heights not exceeding this threshold, the table below may be used. If the Repetitive Group Designator is equal or less than indicated in the row for “No waiting time required” one may move to the height indicated without delay. If the travel may be suspended by 3 hours, the Repetitive Group Designator may equal the one indicated in the row below. Finally the lowest row indicate the number of hours to wait if the Repetitive Group Designator exceeds this. Wait 24 hours before transfer to heights exceeding 250 m asl. if the previous dive has not been attributed a Repetitive Group Designator.

	Altitude (m asl.)		
Wait	250-600	600-1000	1000-1250
No waiting time required	I	H	G
Wait at least 3h	L	J	I
Waiting time (h) with higher Repetitive Group Designator	7	9	11

10. **Rescue divers** may be challenged if scrambled for a rescue mission in mountain waters shortly after sea water routine training. The diver may fly immediately after a dive with Repetitive Group Designator “C” or less. With Repetitive Group Designator “D” or higher, the diver must comply with the guidelines for flying after diving. Rotary wing (helicopter) flying with altitude not exceeding 4000 feet may nevertheless take place immediately after a training dive with Repetitive Group Designator “G” or less. Oxygen breathing during the surface interval will be an effective way of eliminating gas excess and may be used if extraordinary circumstances makes it necessary if the earlier listed limitations cannot be respected. A competent diving physician should be consulted in such cases. The table depth should be adjusted according to the procedure for adjustment of dive site altitude. The bottom time penalty is calculated by the “addition” of Repetitive Group Designator from the previous dive to the Repetitive Group Designator allocated to the specific height of the dive site. If the diver remains at altitude before the rescue dive, this combined Repetitive Group Designator will be reduced according to the Residual Nitrogen Timetable.

11. **Example – flying for a rescue mission after a training dive in sea:**
PROBLEM: A diver has a Repetitive Group Designator of “C” after a training dive and wish to do a rescue dive to 18 m in a mountain water at 1220 m asl. How long bottom time is allowed if this dive should be completed as a no decompression dive? The diver will be transported to the dive site 2 hours after the training dive and will complete his rescue dive immediately after arrival at site.
SOLUTION: The dive to 18m in a mountain lake at 1220 m asl. should be planned according to a table depth of 21 m. The surface interval causes a reduction in the Repetitive Group Designator from “C” to “B” after 2 hours. In addition to this a Repetitive Group Designator of “C” should be added during the movement from sea level to 1220 m altitude. By “adding” Repetitive Group Designators “B” and “C” the diver will be given a new Repetitive Group Designator of “E”. The “E” Repetitive Group Designator will give and additional 25 min of bottom time to the 21 m table. The rescue diver may accordingly plan for 20 min bottom time if the dive should be planned as a no decompression dive.

Multilevel Diving

1. **Background.** Conventional use of the decompression tables assumes that the diver remains at the maximum depth throughout the bottom time. This will be the situation calling for the longest decompression, alternatively dictating the shortest allowed bottom time for a no-decompression dive. If the diver ascends successively to more shallow water, the tissue inert gas supersaturation will decrease. This will allow a longer total dive time without need for staged decompression listed in the dive table and based on maximum depth and running bottom times. Dives characterized with defined time intervals and depth ranges are termed ”multilevel dives”.

2. There are few published procedures for the use of traditional decompression tables for multilevel-diving, but the Canadian (DCIEM) tables include advice for such. It is worth mentioning that there is less evidence associated with use of the tables for multilevel-diving compared to traditional prescription of staged stops. Due to this, we recommend a number of restrictions for such multilevel diving until more data related to safety performance is available.

3. The standard air decompression table can be used for the planning of multilevel dives. The planning is based on the principles of repetitive diving. The dive is separated into discrete steps with certain depth ranges (levels). The tabulated bottom time for any level is calculated by adding the actual bottom time at the step with the Residual Nitrogen Time as dictated by the Repetitive Group Designator. The bottom time for any level should include ascent time to the next shallower level.

4. A number of limitations apply to decompression planning of multilevel-dives:
   - The dive should be executed to successively shallower depths
   - The dive should at any time be finished as a no-decompression dive.
   - The depth levels (steps) should be separated by at least 6m for diving depths not exceeding 30 m and at least 9 m for diving depths exceeding 30 m.
   - The Repetitive Group Designator before and after the dive should not be allowed to exceed ”N”
   - The dive should be completed with a 5 min safety stop between 3 and 6 m.

5. Repetitive dives may be planned for conventionally. Dives to depths not exceeding 6m could be planned for without limitation on bottom time.

6. If maximum allowed dive time at any level is exceeded, the diver should complete a staged decompression as prescribed for this table depth. The diver should breathe oxygen at surface pressure for 30 min after the dive. No repetitive dive is allowed for the next 18 h.

7. The table on the next page may be used for an overview of maximum allowed bottom times at various depth levels depending on the maximum depth of the multilevel dive.
   PROBLEM: A dive is planned for 28 metres. Maximum exploitation of bottom times at all depth levels is wanted. How should the dive be planned?
   SOLUTION: The next deeper table depth is 30 metres. Review the column 30 30 metres and read the maximum bottom time which is 20 min. Next level is 24 metres. The diver has 20 minutes to spend at diving depths ranging between 24 and 30 metres. Maximum allowed bottom time at 24 metres is 5 minutes, next level is 18 metres. The diver may spend 5 minutes at diving depths ranging between 18 and 24 metres. The next level is 12 metres. The diver can spend 10 minutes in diving depths ranging 12 and 18 metres. The diver can spend 40 min shallower than 12 metres. The dive should be completed with a 5 min safety stop between 3 and 6 metres.

8. Multilevel dives with other separation of depth levels. The dive may be planned with other levels/bottom times than those listed as long as the above listed restrictions are respected. This will allow longer dive times at shallower depths.
   PROBLEM: A diver is planning a short (5 min) inspection dive at 32 metres. The rest of the dive is planned to be take place from 18 metres depth to the surface. How could this dive be planned?
   SOLUTION: The bottom time at the deepest level should be planned for 10 min to accommodate ascent time to the next level. We should use the 33 metre table and note that a bottom time of 10 min is penalized with a Repetitive Group Designator of ”D”. The next depth level is 18 metres where Repetitive Group Designator ”D” will give a Residual Nitrogen Time of 25 min. Equivalent bottom time is not allowed to exceed 60 min at 18 metres and such a dive will give a Repetitive Group ”K”. The final part of the dive could be planned with a maximum depth level of either 12 or 9 metres. Actual bottom time should not be allowed to exceed 40 min if the dive is planned with a 12 metre limit. Actual bottom time should not be allowed to exceed 70 min if a maximum diving depth of 9 metres is sufficient. (Repetitive Group Designator ”K” penalize the 9 metre table with 170 min Residual Nitrogen Time.) The diver should execute a 5 min safety stop at the very end of the dive.

9. The table below may be used for calculation of maximum allowed bottom times at various stages of a multilevel dive.

Succeeding depth level (m)	Deepest diving depth (m)								
	39	36	33	30	27	24	21	18	15
39	10								
36		10							
33			15						
30	5			20					
27		10			25				
24	5		10	5		35			
21		10			10		45		
18	10		10	10		10		60	
15		15			15		15		90
12	40		40	40		40		40	
9		45			45		45		45
N2	N	N	N	N	N	N	N	N	N

The table should be read vertically by initially identifying the column listing the deepest diving depth. Maximum allowed bottom times at the various depth levels are listed in the rows below. The bottom time at any depth level should include ascent time to the shallower depth.

Dive Computers

1. **Development.** The first digital dive computers for recreational diving became available in the early 1980s. They were largely based on current algorithms from existing dive tables. These computers did not protect the divers acceptably against DCI. However, as with other electronic devices, the dive computers have developed significantly and exist today in a variety of different versions.

2. **Widespread Use.** Today most recreational divers world-wide use dive computers to monitor their decompression obligation. Dive computers are extensively used by scientific divers and amongst "technical" recreational divers and have additionally gained increasing interest in military diving. Dive computers are used for planning as well as execution of dives and allows a detailed log of the dive.

3. We still do not know whether the use of dive computers will reduce or increase the risk of DCI compared to the use of conventional tables. However, in spite of the increased use of dive computers amongst recreational divers, there is no substantial evidence suggesting increase in DCI incidence.

4. Recreational divers should limit the use of dive computers to no decompression dives. A backup solution should be arranged if a dive is planned that will not allow direct ascent to the surface without decompression penalty (a dive for which the computer requires a ceiling level). Such a backup solution could be the use of another dive computer or a watch/depth gauge. We recommend safety stops for all dives planned with the use of a dive computer

5. **Training.** Divers may be enticed into believing that the risk of DCI is eliminated as long as dives are being conducted according to the computer. This is incorrect – DCI may result from 'correct' computer dives as well as 'correct' table dives. The dive computer is a tool that helps the diver conduct safer dives and this tool should be used wisely. The safe use of dive computers involves proper training.

6. A dive computer is to be considered a personal equipment, and should only be used by yourself. The dive computer is configured with your personal safety factors and monitor your diving activity as well as your gas load. Comply with the most conservative computer if you dive with others. Remember the risk of inert gas narcosis – the dive computer will not warn you against this. If you have to change computer then wait at least 24 hours before the next dive.

7. Dive computers calculate the decompression profile from depth and time. (Some computers include workload as an extra parameter which is estimated based on the diver's air consumption). We recognize several other factors that will affect the decompression requirement, the two primary ones being workload and age. These and other factors are described in the chapter called **Prevention of Decompression Illness.** Hence, this chapter is relevant reading for divers whether they are using dive computers or conventional decompression tables. The use of computers does not relieve the diver from understanding decompression theory.

8. **Algorithms.** Tables as well as computers are based on algorithms. There are many approved tables for diving and there are several acceptable algorithms for programming dive computers. You should nevertheless avoid dives with significant changing depths ("yo-yo dives") and fast ascents. Keep in mind that the safety of the algorithms is less well tested for deep multi-level dives, especially for series of deep multi-level dives. We know that such dives tend to increase the risk of DCI and it makes sense to compensate by choosing wider safety margins.

9. When comparing different dive computers it will commonly be found that decompression requirements differ. This is most likely explained by their use of different algorithms and it is hard to tell which one is safer.

10. Some computers allow adjustment by a user-selected conservatism factor. Where this is an option, the user can set a higher conservatism for age or for dives that are expected to be strenuous.

11. **Occupational diving.** The Norwegian Labour Inspection Authority don't allow the use of dive computers for guidance of diving and decompression. At this time there are no approved standards for design and use of dive computers in in-shore occupational diving. For such dives the diving supervisor is responsible for dive management, depth/time control and decompression supervision according to prepared procedures. Further, since most commercial divers spend the entire bottom time at a fixed depth there is little advantage in using a dive computer. On the contrary, due to the computer's typical extra conservatism, such dive profiles will tend to shorten the bottom time and increase the decompression obligation when using dive computers compared to the use of conventional decompression tables and techniques.

12. Dives with multiple ascents and descents ("yo-yo dives") are expected to predispose to decompression illness even when the boundary maximum dive depth and bottom time are adhered to. When it is impossible to plan the dive avoiding such profiles, a dive computer may be used in addition to conventional decompression tables. A dive computer would be an additional safety tool for such dives, since the computer may identify inappropriate dive profiles and recommend more conservative decompression than the tables. In such cases one should comply with the decompression procedure advised by the dive computer even if the total dive time is shortened compared to what the decompression table prescribe.

13. A dive computer will indicate whether a diver has incurred a decompression commitment, but it will not necessarily show the total decompression time incurred. Further, computer divers may find themselves entering decompression mode, even on dives that were planned to be no-stop dives.

Diving related to oil and gas exploration

1. Petroleum related diving in Norway takes place under the authority of the Norwegian Petroleum Safety Authority and the Norwegian Labour Inspection Authority.

2. **Petroleum related diving regulated by the Petroleum Safety Authority**. The regulations of the Petroleum Safety Authority regulates all petroleum related offshore diving as well as diving on some onshore facilities and pipeline systems as specified by the Framework Regulations. The NORSOK U-100 standard provide additional details.
   Most of the offshore diving takes place with saturation diving techniques. Surface oriented diving is mainly used with light diving crafts. There is a 30 metre depth limitation for diving with light diving crafts and the diving should be done without staged decompression stops. Nitrox may be used to allow extended bottom times for such diving operations.

3. **Petroleum related diving regulated by the Labour Inspection Authority.** The common rule is that the regulations of the Labour Inspection Authority is used for inshore diving even though the diving is related to the petroleum activities. NORSOK U-103 is the recommended standard for such diving. NOSOK U-100 is used for those rare instances of inshore saturation diving.
   NORSOK U-103 give the same recommendations with respect to table use, bottom time restrictions, day exempted from diving and proximity of recompression chambers as NORSOK U-100.

4. **Use of the Norwegian Diving and Treatment Tables for petroleum related diving inshore and offshore:**
   The Norwegian diving and Treatment tables are used for all surface oriented diving, but with bottom time limitations as presented in the Chapter “Prevention of Decompression Illness” and marked in the tables by a thick horizontal line. In addition to this, the dive program shall be designed to ensure that the diver has one day without diving deeper than 9 m for every four days of diving (alternatively 9 m equivalent air depth). Diving to depths shallower than 9 m (or 9 m equivalent air depth) is accepted for air as well as SurDO_2 dives.

5. **An example:**

PROBLEM: A large diving project is to be undertaken at an onshore petroleum pipeline reception facility. The diving is planned for a water depth of 32 metres. The diving procedures should comply with Norsok U-103. Which alternatives should be considered in the planning phase?

SOLUTION: Using air as a breathing gas, the closest table depth will be 33 m. According to Norsok U-103 the bottom time limitation is 40 min at this water depth (25 min of decompression time). An alternative may be to choose Nitrox. pO_2 shall not exceed 1.5 Bar so Nitrox 36 will be slightly too hyperoxic. From the standard gas mixtures we therefore choose Nitrox 32. This will give an EAD of 26,2m at the actual dive depth of 32 m, allowing decompression to be planned according to the 27 m table. This will extend bottom time to 60 min. NORSOK U-103 Rev 3 mandate decompression according to the actual diving depth (33 m table). Because in-water decompression should be restricted to 35 min, the maximum allowed bottom time will be restricted to 45 min using Nitrox 32 and in-water decompression. If the dive is planned as a $SurDO_2$ dive, little is gained if air is used as a breathing gas – the bottom time is still restricted to 40 min and decompression time will be 38 min. Choosing Nitrox 32 will allow extension of the bottom time to 60 min with 73 min decompression time.

Note. This example is valid for NORSOK U-103 Rev 3 (2014). The standard is expected to be revised during 2017.

Oxygen Toxicity

1. **A high partial pressure of oxygen** (pO_2) in the breathing gas (hyperoxia) may cause injury. Various organs may be involved, depending on pO_2 and exposure time. The main concerns are related to the central nervous system (acute oxygen toxicity) and the lungs (‘chronic’ or pulmonary oxygen toxicity). It seems that the damage is being caused by free radicals – that is, short-lived, highly reactive oxygen compounds that cause cellular damage or dysfunction.

2. **Acute oxygen toxicity**. A high pO_2 affects the central nervous system (brain and spinal cord) directly and may cause convulsion and loss of consciousness. Some divers may get warning symptoms like minor muscular twitches (around lips and eyes), tingling sensation in fingers, tunnel vision or vertigo and uneasiness. Other early symptoms may be visual or auditory impairment, confusion, euphoria or troubled breathing. Unfortunately such warnings are unreliable and may be too vague to raise the diver’s attention. It is thus impossible to predict when serious symptoms may arise. The time from the onset of symptoms until a diver convulses may be anything from a few seconds to about an hour.

3. **Risk Factors**. The risk of suffering from acute oxygen toxicity increases with pO_2 and exposure time. Further, it seems that a submerged diver is more susceptible than a diver in a dry hyperbaric chamber, given the same pO_2 and exposure time. Other known factors that increase the susceptibility are:

   – High level of physical activity
   – Increased level of CO_2
   – (Strong) auditory or visual stimulation
   – Vibrations
   – Chilling (hypothermia), over-heating (hyperthermia) and fever

4. **‘Chronic’ or pulmonary oxygen toxicity** is a pulmonary injury. A high pO_2 causes reduced pulmonary diffusion capacity, reduced airflow through the small airways and reduced pulmonary elasticity. The first detectable symptoms are chest soreness and shortness of breath. Further damage causes coughing and painful respiration. It was previously believed that pulmonary damage was fully reversible, even in severe cases. Today we know that permanent damage may ensue, as evidenced by a persistent decrease in some measures of pulmonary function. Still, divers who have been exposed to moderate oxygen poisoning, for example by being treated for DCI or a prolonged series of dives with $SurDO_2$ will rarely notice any decrease in pulmonary capacity. However, after years of diving a few divers do develop detectable symptoms of pulmonary impairment.

5. Pulmonary oxygen toxicity is mainly associated with nitrox diving, $SurDO_2$ and last but not least, hyperbaric oxygen treatment for DCI. However, one ought to limit hyperoxia for all diving and saturation diving in particular. The severity of oxygen poisoning increases with pO_2 and exposure time.

6. In operational Nitrox diving, the main factor limiting diving depth and bottom time (in addition to the decompression time) will be the risk of acute oxygen toxicity. However, chamber dives involving long periods of high pO_2, pulmonary oxygen toxicity will be the main concern. Granted, the risk of acute poisoning may also be an issue in a dry chamber but the consequences are less serious.

7. We should be particularly concerned about the cumulative effect of a high pO_2. A single nitrox dive, even with surface decompression including chamber oxygen breathing will not be of any immediate concern regarding pulmonary oxygen toxicity. However, repetitive and long nitrox dives, with or without surface decompression on oxygen may cause problems. We will discuss the subject of oxygen exposure in the paragraphs below.

8. **Oxygen Tolerance Unit** (OTU) is a measure of oxygen exposure that has been devised to assess the risk of pulmonary oxygen poisoning. (The same unit used to be called UPTD – Unit of Pulmonary Toxicity Dose). One OTU represents the toxic effect of breathing pure oxygen at one atmosphere for one minute. When the pO_2 equals one bar one can easily calculate the total dose by counting the minutes of exposure. Any pO_2 equal to or less than 0.5 bar is assumed to cause no pulmonary toxicity regardless of exposure time.

9. **Pressure Dependent Constant.** To estimate the OTU for a pO_2 exceeding 0.5 we have to calculate the effects caused by one minute of breathing in relation to that caused by one OUT. This relation is given by a pressure-dependent factor termed k_p. k_p is calculated according to this equation:

$$k_p = \sqrt[1,2]{\frac{pO_2 - 0,5}{0,5}}$$

10. Total oxygen exposure in terms of OTU's is found by multiplying k_p by the exposure time (min). For convenience the table on the next page provides k_p directly as a function of pO_2.

11. **Total Exposure.** When assessing total oxygen exposure for a dive with varying pO_2 the total exposure is found by calculating OTU's for all pO_2 levels individually and then adding them together. When the pressure changes linearly a good approximation will be to use the mean depth.

12. **Table for k_p as a function of pO_2**

pO_2	k_p
0,6	0,26
0,7	0,47
0,8	0,65
0,9	0,83
1,0	1,00
1,1	1,16
1,2	1,32

pO_2	k_p
1,3	1,48
1,4	1,63
1,5	1,78
1,6	1,93
1,7	2,07
1,8	2,22
1,9	2,36

pO_2	k_p
2,0	2,50
2,1	2,64
2,2	2,77
2,3	2,91
2,4	3,04
2,5	3,17
2,6	3,31

pO_2	k_p
2,7	3,44
2,8	3,57
2,9	3,70
3,0	3,82
3,1	3,95
3,2	4,08
3,3	4,20

13. PROBLEM: You dive to 30 m for 60 min breathing nitrox containing 32 % oxygen. The decompression is planned as a SurDO_2 dive, and 15 min of O_2 breathing is prescribed at 15 m and 30 min of O_2 breathing at 12 m. What is your OTU score, disregarding the exposure during descent and ascent?

SOLUTION:a. 32 % O_2 at 30 m gives a pO_2 of 1.28 bar
k_p for 1.28 bar (use 1.3 bar in the k_p table) = 1.48
OTU Score = $k_p \cdot$ time (min) = $1.48 \cdot 60$ = 89

b. 100 % O_2 at 15 and 12 m gives a pO_2 of 2.5 and 2.2 bar
k_p for 2.5 bar = 3.17, k_p for 2.2 bar = 2.77
OTU Score = $k_p \cdot$ time (min)
OTU score at 15m = $3.17 \cdot 15$ = 48
OTU score at 12m = $2.77 \cdot 30$ = 83

Total oxygen dose: 89 + 48 + 83 = **220 OTU**

14. **Maximum Safe Oxygen Doses.** When diving for a week or more, the average daily exposure should not exceed 300 OTU, i.e. no more than 2100 OTU per week. Still, for a single week 2660 OTU is acceptable, provided the daily exposure is less than 850 OTU. Regarding hyperbaric treatment of DCI the advised limit used to be 1425 OTU, the rationale being that this level of exposure is expected to cause a 10 % decrease in vital capacity in 50 % of the subjects. Today the main priority is to ensure complete resolution of the DCI to avoid residual neurological damage, even if the number of OTUs should exceed the recommended limits. Clinical experience supports this priority since the patients rarely experience or complain of permanent loss in lung function, even after a long series of therapeutic exposures.

15. **Air Breaks.** Scientific tests as well as practical experience have shown that intermittent periods with a lower pO_2 (for instance, by breathing chamber air) will delay the onset of acute as well as chronic oxygen poisoning. Thus, a five min air break is advised for every 20 – 30 min period on oxygen during a therapeutic dive, except during decompression. Several experiments confirm that air breaks extend the total oxygen exposure tolerance considerably. Still, one should be cautious about repetitive exposure to high-level hyperoxia.

Nitrox Diving

1. Nitrox is a mixture of nitrogen and oxygen in different proportions than the composition of air. For a long time nitrox has been used as a breathing gas for divers, in open circuit systems as well as rebreathers. We will look into the use of open-circuit nitrox with a higher oxygen fraction than air. Such mixtures are commonly known as oxygen-enriched air or enriched air nitrox (EAN).

2. Breathing a gas with higher oxygen content than air allows longer bottom time without incurring a higher decompression obligation. The reason for this is that the partial pressure of nitrogen (rather than depth per se) and time decide the table depth. Thus, by replacing some of the nitrogen with oxygen we may decompress according to a shallower table depth. Further, during the decompression phase of the dive the higher oxygen content will provide a safer and more efficient decompression.

3. **Equivalent Air Depth** (EAD) is a key concept in nitrox diving. It is the depth at which air would provide the same nitrogen partial pressure as the actual nitrox mix at a given depth.

4. EXAMPLE: You dive to 30 m using a nitrox mixture composed of 40 % oxygen and 60 % nitrogen. The absolute pressure at 30 m is 4 bar, hence the nitrogen partial pressure will be 60 % of bar = 2.4 bar. The EAD will be the depth where air provides 2.4 bar of nitrogen, namely 20.4 m. In other words, we may dive to 30 m using this gas mixture and plan the dive according to the 21 m air table. In practical terms this means an increase in no-stop time from 20 to 45 min.

5. The following equation gives equivalent air depth:

$$EAD = \frac{(D + 10) \times N}{79} - 10$$

   D represents depth in metres
   N represents the percentage of nitrogen in the nitrox mixture

6. **Safe Oxygen Limits.** From a decompression perspective the highest possible oxygen fraction will be the most advantageous. However, the risk of oxygen toxicity limits the safe use of oxygen. The individual susceptibility for acute oxygen toxicity varies significantly from one day to another. During the bottom phase of a dive, the pO2 shall not be allowed to exceed 1.5 Bar, but it may be increased to 1.6 Bar during in-water decompression.

7. **Oxygen Toxicity.** For all diving operations involving nitrox the diver as well as the surface support must consider the risk of oxygen toxicity. This is particularly important whenever the exposures approach the threshold levels. In surface supplied diving, provisions must be made to allow an instant gas switch to air. For hard hats it is important to ensure a constant and sufficient gas flow to avoid the risk of a CO_2 build-up. Should a diver ever suspect an attack of oxygen toxicity he must notify the diving supervisor immediately. In this situation, breathing gas should be switched from nitrox to air. Keep in mind that the first and only sign of oxygen poisoning may be a vague, uncanny feeling of 'something's wrong'. Whenever a case of oxygen convulsion is suspected or confirmed the diver should promptly be brought back to the surface, disregarding the risk of pulmonary barotrauma due to gas expansion during ascent. Obviously the risk of drowning is the most imminent problem, particularly when a convulsing diver isn't protected by a hard hat or a full-face mask.

8. **Nitrox mixes.** Ideally having a large number of gas mixes available could minimize the decompression obligation for any profile. However, logistical considerations make it more prudent to use a set of standard mixes, thereby limiting the risk of confusion and error. The standard mixes contain 32, 36 and 40 % oxygen respectively. We recommend the use of these mixes for open circuit diving. For dives involving surface decompression we recommend the use of one standard mix only, namely the 32 % oxygen mix. A nitrox mix is identified by its oxygen fraction or alternatively as the oxygen fraction/nitrogen fraction. A mix containing 40 % oxygen will thus be referred to as Nitrox 40 or as Nitrox 40/60.

9. **Tolerance and Labelling.** The tolerance is ± 0.5 % for the oxygen and nitrogen in a nitrox mix. Whenever a mix falls within this tolerance we may use the maximum oxygen depth or the equivalent air depth of its nominal value (e.g. for calculation of maximum allowed pO_2 with respect to oxygen toxicity or for the calculation of equivalent air depth). However, when a nitrox mix has a different composition than anticipated the consequences may be serious. Thus, we advise the use of dedicated cylinders for each mix including air. Each cylinder should be labelled and painted according to international standards.

10. **Nitrox and Decompression Stops.** Nitrox divers using the standard table may decompress at a greater depth without increasing the stop time. In principle, the stop depth may be increased until the actual nitrogen partial pressure matches that of air at the prescribed stop depth. To simplify one may shift the ascent profile to the next greater standard depth increment, that is, the 3 m stop may be performed at 6 m and so on. The only prerequisite is that the breathing gas contains at least 36 % oxygen. Dives with lower oxygen fraction should not adjust the depths of the decompression stops. A deeper stop profile is particularly useful whenever swells/wave action make it difficult or uncomfortable to spend time at shallow depths. Air divers may use the same procedure provided they switch to nitrox 36 or higher during the ascent.

Surface Decompression Using Oxygen

1. **Surface Decompressio**n breathing oxygen in the pressure chamber (SurDO$_2$) is a decompression technique using in-water stops up to a depth of 12 m. Then the diver surfaces and is promptly recompressed to a depth of 15 m in a hyperbaric chamber where he breathes oxygen supplied through a mask. This procedure requires a pressure chamber with a main lock and an entry lock as well as provisions for oxygen breathing.

2 **Fire Hazard.** The divers breathing gas should be supplied through breathing masks (BIBS) with an exhaust line expelling the exhaled gas out of the chamber. Further, the chamber must be equipped with sensors to allow continuous oxygen monitoring. Even a small increase in chamber oxygen fraction presents a substantial fire hazard. Fire in a hyperbaric chamber is a catastrophic event. While the overboard dump ensures that most of the oxygen is evacuated without enriching the chamber atmosphere minor leaks around the breathing mask may increase chamber oxygen content. The oxygen fraction shall not be allowed to exceed 23 %. Hence, whenever the oxygen percentage rises the chamber should be flushed with air. When uncontrolled leaks are suspected these must be located and repaired promptly. Keep in mind that the oxygen concentration may be much higher close to the leak than readings from the oxygen sensors to indicate.

3. **Deep in-water recompression.** Since the last in-water stop is at a depth of 12 m the diver will be much less likely to be affected by swell and surge than he would be at a 3 m stop. Further, since the total in-water decompression time tends to be less with SurDO$_2$ this procedure has major operational advantages. This is beneficial for the diver as he will avoid excessive decompression time in cold water.

4. **Nitrox** is a good choice for in-water breathing gas for SurDO$_2$ dives. However, we advise the use of EAN 32 (32 % oxygen) only. This mix represents the optimal balance between limiting the decompression obligation and avoiding an undue exposure to a high pO$_2$. The exposure limits for oxygen listed in the chapter of Nitrox diving must be respected.

5. **Using the Table.** The table will be used in the same way as for ordinary dives. That is, select a table that matches the actual depth (for nitrox, the EAD) or the next deeper table depth. The bottom time runs from the moment the diver leaves the surface until he leaves the bottom on the final ascent. Table-wise this means rounding off to the next longer bottom time unless there is a table time listed that matches the bottom time exactly.

6. **The Ascent Rate** to the first decompression stop and between the decompression stops should be 10 m/min. Minor deviations are acceptable and it is better to be too slow than too fast. The travel times listed for the deepest decompression stop is the time the diver should stay at this depth. The time listed for shallower stops include the ascent time from the deeper stop. Any major delays during the deeper part of the ascent should be compensated by switching to a longer bottom time, thus increasing the decompression penalty.

7. **The Surface Interval** should be as short as possible. The maximum time from leaving the 12 m stop until the diver is recompressed to 15 m in the chamber is 5 min. The surface intervals run from the time the diver ascends past 12m for those dives that do not require in-water decompression stops. The ascent time from 12 m to the surface should be approximately one minute and the recompression to 15 m in the chamber will usually take about 30 seconds. Hence, the diver has three and a half minutes to leave the water, remove the equipment and enter the chamber. Usually, this is more than enough time. However, the diver should be aided in removing his diving gear and be subject to minimal strain and exertion. He should be assisted by two persons. It is important to practice the procedure and the exact order of events and assign specific tasks to each member of the team. Under no circumstances should the ascent rate from the 12 m stop be increased to try to gain time! If surface interval exceeds 5 minutes, recompress the diver on Table 5. (This is not considered as treatment.)

8. **Chamber Decompression.** Oxygen breathing should commence as soon as the diver has entered the chamber and continue for the recompression. The chamber should be pressurized as soon as the hatch is closed and secured, whether the diver has put on the oxygen mask or not. The chamber is recompressed fast (during some 30 sec) to 15 metre. The first 15 min of the oxygen breathing time shall take place at 15 metre. The chamber is then decompressed approx. 10 m/min to 12 m (approximately 20 sec decompression time) where the remaining of the oxygen breathing takes place. The decompression rate to surface pressure (from 15 or 12 m) is 10 m/min. The diver shall breathe from the chamber atmosphere (compressed air) during decompression to surface pressure. If the decompression time from 12 m to surface is violated due to technical limitations of the decompression chamber, the diver should be decompressed at a rate of 10 m/min as long as possible. Too slow decompression at the terminal phase of decompression should not be compensated by accelerated decompression at the deepest part. The diver should breathe chamber gas throughout decompression even if decompression time from 12 m to surface is extended.

9. **Air Breaks.** After each 30 min of oxygen breathing the diver removes the mask and breathes chamber air for 5 min. There should be no air break after the last oxygen session before commencing the chamber decompression. These air breaks are not to be counted as oxygen time nor are any unplanned interruptions of the oxygen breathing periods. No more than 15 min of extra air breaks should be added.

10. **The Total Decompression Time** listed in the last column is defined as the time from the diver leaves the bottom until he returns to the surface following the chamber run. This includes the 5 min air breaks following each 30 min of oxygen breathing. Additional unplanned air breaks are not included. The time listed may differ from the actual by one minute due to rounding of numbers.

11. **Oxygen Toxicity.** Oxygen seizures in a chamber at 15 or 12 metres are unlikely. Nonetheless, should seizures occur the oxygen mask should be removed immediately and the patient decompressed 3 m at a rate of 0,3 m/min as soon as the seizures subside. Pending the diving physician's approval oxygen breathing may be resumed at 9 m (or 12 m). If the diving physician cannot be reached within 15 min of the incident oxygen breathing should not be resumed. In this case enter Table 1 at 9 m (or 12 m) and follow this schedule to the surface. This gives 4 hrs, 21 min (or 5 hrs 1 min) remaining decompression. Such use of Table 1 is not considered a therapeutic procedure.

12. **If the oxygen supply should fail** the diver will breathe chamber atmosphere at the current depth. Provided the oxygen supply is re-established within 15 min oxygen breathing will resume. In this case the oxygen period should be extended to make up for the interruption. Whenever the oxygen supply cannot be re-established within 15 min a switch to Table 1 at 12 m is warranted. The use of Table 1 in this situation is not considered a therapeutic procedure.

13. **Repetitive dives.** SurDO_2 dives should not be a repetitive dive, neither should a repetitive dive be planned after a SurDO_2 dive. The minimum surface interval required for a new single dive is determined conventionally based on the Repetitive Group and the table for adjustment of Repetitive Group during the surface interval. A number of profiles are not associated with a Repetitive Group. For such profiles a minimum of 18 hours should pass before the next dive. A second dive to a depth not exceeding an actual or EAD of 6 m is allowed after any dive.

14. **Diving for consecutive days** increases the risk of DCI. This is particularly true for deep SurDO_2 dives, and especially when the dives have been strenuous or the bottom times have been close to the table limit. The diver shall therefore have a day with no diving after each three day period of diving. As always, the only exception is dives to a depth of 9 m or less, including nitrox dives to an EAD of 9 m or less. Within this context, such shallow dives are not considered repetitive dives and may be carried out on a 'no diving day' without invalidating the break.

15. **Bottom time limitations and "exceptional dives"**. Dives carrying a risk ranging 5-6% or requiring more than 90 min of chamber oxygen breathing are identified by asterisk. Dives should not be planned for these exceptional bottom times. Petroleum related diving (diving according to the Norwegian petroleum regulations) should comply with UK bottom time regulations. Bottom times exceeding UK bottom time limitations are listed below the horizontal bold line in the tables.

16. **Predisposing Factors.** To compensate for factors known to increase the risk of DCS, the chamber oxygen time may be increased and/or a shorter bottom time selected.

17. **Oxygen Exposure.** To easier keep track of the oxygen exposure during SurDO_2 dives, the table below may be used. The table shows the oxygen exposure in OTU depending on oxygen breathing time.

	Oxygen breathing time (min)						
	15	30	45	60	75	90	105
Oxygen exposure (OTU)	48	89	131	172	214	255	297

18. **Example 1:** SurDO_2 dive with staged in-water decompression stops
PROBLEM: A SurDO_2 dive is planned for to 29m with air as the breathing gas. The dive is planned as a conventional in-shore dive regulated by the Norwegian Labour Inspection Authority (not NORSOK U-103). What is the longest bottom time that may be planned for and how should the dive be executed?
SOLUTION: The 30 metre table must be used, the longest bottom time that is allowed is 100 min. At the end of the bottom time, the diver should ascend approximately 10 m/min to the 12m stop. This will take about 2 min. At arrival on 12m the time start running for the 12m water stop. The diver should stay at the 12m stop for 9 minutes. The decompression time (from start of the ascent from bottom) is now 11 min. The divers ascend at a rate of approximately 10 m/min to surface. He should be helped with his equipment and has approximately 4 min to undress his diving equipment, to enter the chamber and being recompressed to 15 metres. At arrival 15m the time for oxygen breathing time starts running (even if the diver had started oxygen breathing during descent). The diver breathes O_2 on BIBS and after 15 min at 15 m the chamber is decompressed 10 m/min to 12 metres. After 30 min of O_2 breathing (15 min at 15 m and 15 min at 12 m) the diver should remove his BIBS-mask for 5 min . The running time for oxygen breathing is paused during the air break. The diver repeats this sequence of 30 min oxygen breathing twice with an interspaced air break of 5 min. The diver has now breathed O_2 for a total of 90 min and 116 min have passed since start of ascent (2 min to 12 m water stop, 9 min stop at the 12 m stage, 5 min surface interval, 90 min of oxygen breathing, 10 min air breaks). The diver removes his BIBS mask and the chamber

is decompressed 10 m/min to surface pressure (1 min). The diver is at surface 117 min after the ascent started.

19. **Example 2:** SurDO_2 dive without in-water decompression stop
PROBLEM: A dive to 26 metre is planned within the regulations of the Norwegian Labour Inspection Authority (not Norsok U-103) to the maximum bottom time. How should this be planned?
SOLUTION: The 27 m table must be used, this table allows a maximum of 110 min bottom time. At the end of the bottom time, the diver ascends slowly (approximately 10 m/min). The time for surface interval starts running as the diver passes 12 m water depth. When the diver reaches surface, approximately 3 min after the start of ascent, he should be supported when removing his diving gear. He should be breathing O_2 on BIBS at 15 m in the chamber no later than 5 min after start of the surface interval (7 min after start of ascent). After 15 min of oxygen breathing at 15 m the chamber is decompressed to 12 m. After further 15 min of oxygen breathing at 12 m the diver removes his BIBS mask for a 5 min air break. This oxygen breathing cycle is repeated twice at 12 m (totally 90 min of O_2, 10 min air breaks). There is no need for an air break after the last O_2 breathing period – the diver will remove his BIBS-mask and the chamber is decompressed 10 m/min to surface pressure. The total decompression time is 107 min (1 min to 12m, 5 min surface interval, 90 min O_2 breathing, 10 min air breaks, 1 min decompression to surface pressure). This deviate 1 min from the time presented in the table. The reason is that decompression time is calculated from a table depth of 27 m. The rounding of numbers causes an extra minute to be added to the total decompression time.

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repeti-tive group
		15	12	9	6	3		
6 metres	25	–	–	–	–	–	–	A
	45	–	–	–	–	–	–	B
	60	–	–	–	–	–	–	C
	80	–	–	–	–	–	–	D
	105	–	–	–	–	–	–	E
	135	–	–	–	–	–	–	F
	165	–	–	–	–	–	–	G
	205	–	–	–	–	–	–	H
	240	–	–	–	–	–	–	I
	255	–	–	–	–	–	–	I
	330	–	–	–	–	–	–	J
	>330	–	–	–	–	–	–	K

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K
25	45	60	85	105	135	165	205	255	330	460

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
9 metres	15	–	–	–	–	–	–	A
	25	–	–	–	–	–	–	B
	40	–	–	–	–	–	–	C
	50	–	–	–	–	–	–	D
	60	–	–	–	–	–	–	E
	75	–	–	–	–	–	–	F
	90	–	–	–	–	–	–	G
	105	–	–	–	–	–	–	H
	125	–	–	–	–	–	–	I
	145	–	–	–	–	–	–	J
	165	–	–	–	–	–	–	K
	195	–	–	–	–	–	–	L
	225	–	–	–	–	–	–	M
	240	–	–	–	–	–	–	N
	260	–	–	–	–	–	–	N
	305	–	–	–	–	–	–	O
	370	–	–	–	–	–	–	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
20	30	40	50	65	75	90	110	125	145	170	195	225	260	310	370

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
12 metres	10	–	–	–	–	–	–	A
	20	–	–	–	–	–	–	B
	25	–	–	–	–	–	–	C
	35	–	–	–	–	–	–	D
	45	–	–	–	–	–	–	E
	55	–	–	–	–	–	–	F
	65	–	–	–	–	–	–	G
	75	–	–	–	–	–	–	H
	85	–	–	–	–	–	–	I
	95	–	–	–	–	–	–	J
	110	–	–	–	–	–	–	K
	120	–	–	–	–	–	–	L
	135	–	–	–	–	–	–	M
	150	–	–	–	–	–	–	N
	160	–	–	–	–	–	–	O
	165	–	–	–	–	5	5	O
	195	–	–	–	–	10	10	Z
	225	–	–	–	–	15	15	Z
	240	–	–	–	–	35	35	Z
	270 *	–	–	–	–	45	45	Z

Repetitive group adjusted for surface interval															
A 15	B 20	C 30	D 35	E 45	F 55	G 65	H 75	I 85	J 95	K 110	L 120	M 135	N 150	O 170	Z 190
Minutes to be added to the bottom time for a repetitive dive															

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
15 metres	10	–	–	–	–	–	–	A
	15	–	–	–	–	–	–	B
	20	–	–	–	–	–	–	C
	30	–	–	–	–	–	–	D
	35	–	–	–	–	–	–	E
	40	–	–	–	–	–	–	F
	50	–	–	–	–	–	–	G
	55	–	–	–	–	–	–	H
	65	–	–	–	–	–	–	I
	70	–	–	–	–	–	–	J
	80	–	–	–	–	–	–	K
	90	–	–	–	–	–	–	L
	105	–	–	–	–	5	5	O
	120	–	–	–	–	10	10	O
	135	–	–	–	–	15	15	Z
	145	–	–	–	–	20	20	Z
	160	–	–	–	–	25	25	Z
	180 *	–	–	–	5	25	30	Z
	190 *	–	–	–	20	40	60	Z

Repetitive group adjusted for surface interval															
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	15	25	30	35	40	50	55	65	75	80	90	100	110	120	130
Minutes to be added to the bottom time for a repetitive dive															

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
18 metres	5	–	–	–	–	–	–	A
	10	–	–	–	–	–	–	B
	15	–	–	–	–	–	–	C
	20	–	–	–	–	–	–	D
	30	–	–	–	–	–	–	E
	35	–	–	–	–	–	–	F
	40	–	–	–	–	–	–	G
	45	–	–	–	–	–	–	H
	50	–	–	–	–	–	–	I
	55	–	–	–	–	–	–	J
	60	–	–	–	–	–	–	K
	70	–	–	–	–	5	5	L
	80	–	–	–	5	5	10	N
	90	–	–	–	5	10	15	O
	100	–	–	–	5	15	20	Z
	110	–	–	–	5	20	25	Z
	120	–	–	–	5	25	30	Z
	130 *	–	–	–	20	40	60	Z
	140 *	–	–	5	30	40	75	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	15	20	25	30	35	40	45	50	60	65	70	80	85	95	100

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
21 metres	5	–	–	–	–	–	–	A
	10	–	–	–	–	–	–	B
	15	–	–	–	–	–	–	C
	20	–	–	–	–	–	–	D
	25	–	–	–	–	–	–	E
	30	–	–	–	–	–	–	G
	35	–	–	–	–	–	–	H
	40	–	–	–	–	–	–	I
	45	–	–	–	–	–	–	J
	50	–	–	–	–	5	5	K
	55	–	–	–	–	5	5	L
	60	–	–	–	5	5	10	M
	70	–	–	–	5	10	15	N
	75	–	–	–	5	15	20	O
	85	–	–	–	5	20	25	Z
	90	–	–	–	5	25	30	Z
	95 *	–	–	5	5	25	35	Z
	110 *	–	–	5	20	45	70	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
10	10	15	20	25	30	35	40	45	50	55	60	65	70	75	85

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
24 metres	5	–	–	–	–	–	–	A
	10	–	–	–	–	–	–	C
	15	–	–	–	–	–	–	D
	20	–	–	–	–	–	–	E
	25	–	–	–	–	–	–	F
	30	–	–	–	–	–	–	H
	35	–	–	–	–	–	–	I
	40	–	–	–	–	5	5	J
	50	–	–	–	5	5	10	M
	55	–	–	–	5	10	15	M
	60	–	–	–	5	15	20	N
	70	–	–	–	5	20	25	O
	80 *	–	–	5	5	30	40	Z
	85 *	–	–	5	20	40	65	Z
	90 *	–	5	5	30	45	85	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	10	15	20	20	25	30	35	40	40	45	50	55	60	65	70

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
27 metres	5	–	–	–	–	–	–	B
	10	–	–	–	–	–	–	C
	15	–	–	–	–	–	–	E
	20	–	–	–	–	–	–	F
	25	–	–	–	–	–	–	G
	30	–	–	–	–	5	5	I
	40	–	–	–	5	5	10	L
	45	–	–	–	5	10	15	M
	50	–	–	–	5	15	20	N
	55	–	–	–	5	20	25	O
	60	–	–	5	5	20	30	O
	65 *	–	–	5	5	25	35	Z
	70 *	–	–	5	10	30	45	Z
	75 *	–	–	5	30	45	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	10	10	15	20	20	25	30	35	35	40	45	50	50	55	60

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min)	Repetitive group
		15	12	9	6	3		
30 metres	5	–	–	–	–	–	–	B
	10	–	–	–	–	–	–	D
	15	–	–	–	–	–	–	E
	20	–	–	–	–	–	–	G
	25	–	–	–	–	5	5	H
	30	–	–	–	5	5	10	J
	35	–	–	–	5	10	15	L
	40	–	–	–	5	15	20	M
	45	–	–	–	5	20	25	N
	50	–	–	5	5	20	30	O
	55 *	–	–	5	5	25	35	Z
	60 *	–	–	5	10	30	45	Z
	65 *	–	5	5	30	40	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	10	10	15	15	20	25	25	30	35	35	40	45	45	50	55

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
33 metres	5	–	–	–	–	–	–	B
	10	–	–	–	–	–	–	D
	15	–	–	–	–	–	–	F
	20	–	–	–	–	5	5	H
	25	–	–	–	5	5	10	I
	30	–	–	–	5	10	15	K
	35	–	–	–	5	15	20	M
	40	–	–	–	5	20	25	N
	45	–	–	5	5	20	30	O
	50 *	–	–	5	10	25	40	Z
	55 *	–	5	5	20	40	70	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	10	10	15	15	20	20	25	25	30	35	35	40	40	45	50

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
36 metres	10	–	–	–	–	–	–	D
	15	–	–	–	–	5	5	F
	20	–	–	–	–	5	5	H
	25	–	–	–	5	5	10	J
	30	–	–	–	5	15	20	L
	35	–	–	–	5	20	25	N
	40	–	–	5	5	25	35	O
	45 *	–	–	5	10	25	40	Z
	50 *	–	5	10	25	40	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	10	10	15	15	20	20	25	25	30	30	35	40	40	45

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
39 metres	10	–	–	–	–	–	–	F
	15	–	–	–	–	5	5	G
	20	–	–	–	5	5	10	I
	25	–	–	–	5	10	15	K
	30	–	–	–	5	20	25	M
	35 *	–	–	5	5	20	30	O
	40 *	–	–	5	10	25	40	Z
	45 *	–	5	10	25	40	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	10	10	15	15	20	20	20	25	25	30	30	35	35	40

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
42 metres	10	–	–	–	–	5	5	E
	15	–	–	–	5	5	10	H
	20	–	–	–	5	10	15	J
	25	–	–	–	5	15	20	L
	30	–	–	5	5	20	30	N
	35 *	–	5	10	15	35	65	O
	40 *	–	5	15	20	40	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	10	10	10	15	15	20	20	25	25	25	30	30	35	35

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
45 metres	10	–	–	–	–	5	5	F
	15	–	–	–	5	5	10	H
	20	–	–	–	5	15	20	K
	25	–	–	5	5	20	30	M
	30 *	–	–	5	10	25	40	O
	35 *	–	5	15	20	40	80	Z

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	10	10	10	15	15	15	20	20	25	25	30	30	30	35

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
48 metres	10	–	–	–	5	5	10	F
	15	–	–	–	5	10	15	I
	20	–	–	5	5	15	25	L
	25	–	–	5	10	20	35	N
	30 *	–	5	5	10	25	45	O

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	5	10	10	15	15	15	20	20	20	25	25	30	30	30

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
51 metres	10	–	–	–	5	5	10	G
	15	–	–	–	5	10	15	J
	20	–	–	5	5	15	25	L
	25 *	–	–	5	10	25	40	O
	30 *	5	5	15	25	35	85	Z

Repetitive group adjusted for surface interval															
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	5	10	10	10	15	15	15	20	20	20	25	25	30	30
Minutes to be added to the bottom time for a repetitive dive															

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
54 metres	10 *	–	–	–	5	5	10	G
	15 *	–	–	5	5	10	20	K
	20 *	–	–	5	10	15	30	M
	25 *	–	5	5	10	25	45	O

Repetitive group adjusted for surface interval

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	5	10	10	10	15	15	15	20	20	20	25	25	25	30

Minutes to be added to the bottom time for a repetitive dive

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
57 metres	10 *	–	–	–	–	10	10	H
	15 *	–	–	5	5	15	25	K
	20 *	–	–	5	10	20	35	N
	25 *	–	5	5	15	25	50	Z

Repetitive group adjusted for surface interval															
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Z
5	5	5	10	10	10	10	15	15	15	20	20	20	25	25	25
Minutes to be added to the bottom time for a repetitive dive															

Standard Air Decompression Table

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)					Total decomp. time (min.)	Repetitive group
		15	12	9	6	3		
60 metres	10∗	–	–	–	–	15	15	H
	15∗	–	–	–	10	15	25	L
	20∗	–	5	10	15	30	60	O

Residual Nitrogen Timetable for Repetitive Dives

Surface Interval Times are given as Times:Minutes

	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A →																0:10 2:20
B →															0:10 1:20	1:21 3:40
C →														0:10 1:00	1:01 2:10	2:11 4:30
D →													0:10 0:50	0:51 1:50	1:51 3:00	3:01 5:20
E →												0:10 0:50	0:51 1:40	1:41 2:40	2:41 4:00	4:01 6:20
F →											0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:50	4:51 7:10
G →										0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:40	5:41 8:00
H →									0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:20	5:21 6:30	6:31 8:50
I →								0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:20	7:21 9:40
J →							0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 8:20	8:21 10:40
K →						0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 9:10	9:11 11:30
L →					0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 8:40	8:41 10:00	10:01 12:20
M →				0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 8:40	8:41 9:40	9:41 10:50	10:51 13:10
N →			0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 8:40	8:41 9:30	9:31 10:30	10:31 11:50	11:51 14:10
O →		0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 8:40	8:41 9:30	9:31 10:30	10:31 11:20	11:21 12:40	12:41 15:00
Z →	0:10 0:50	0:51 1:40	1:41 2:40	2:41 3:30	3:31 4:20	4:21 5:10	5:11 6:10	6:11 7:00	7:01 7:50	7:51 8:40	8:41 9:30	9:31 10:30	10:31 11:20	11:21 12:10	12:11 13:30	13:31 15:50
	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

Repetitive group adjusted for surface interval

Corrections for Dive Site Altitude

	Altitude (metres above sea level)							Use table for
	250-500	500-750	750-1000	1000-1250	1250-1500	1500-1750	1750-2000	
Depth in metres not to exceed:	8	8	7	7	7	7	7	9 m
	11	10	10	10	10	9	9	12 m
	14	13	13	12	12	12	11	15 m
	16	16	15	15	15	14	14	18 m
	19	19	18	18	17	17	16	21 m
	22	21	21	20	20	19	18	24 m
	25	24	23	23	22	21	21	27 m
	28	27	26	25	25	24	23	30 m
	31	30	29	28	27	26	25	33 m
	33	32	31	30	30	29	28	36 m
	36	35	34	33	32	31	30	39 m
	39	38	37	36	35	33	32	42 m
	42	41	39	38	37	36	35	45 m
	45	43	42	41	40	38	37	48 m
	48	46	45	43	42	41	40	51 m
	50	49	47	46	45	43	42	54 m
	53	52	50	49	47	46	44	57 m
	56	54	53	51	50	48	47	60 m
	A	B	B	C	D	E	F	
	Repetitive group for altitude exposure							

Corrections for Depth of Decompression Stops

Altitude metres	250-500	500-750	750-1000	1000-1250	1250-1500	1500-1750	1750-2000	Re-placing
Adjusted depth of Staged Stops	No adjustments							3 m
						5	5	6 m
				8	8	8	8	9 m
			11	11	11	10	10	12 m
			14	14	13	13	13	15 m
		17	17	16	16	15	15	18 m

EAD-table for Open-Circuit Nitrox with 32 % O_2

(Dives should not be planned to depths indicated by italics)

Depth (metres)	EAD (metres)	Use table (metres)	pO_2 (Bar)
12	8,9	9	0,70
13	9,8	12	0,74
14	10,7	12	0,77
15	11,5	12	0,80
16	12,4	15	0,83
17	13,2	15	0,86
18	14,1	15	0,90
19	15,0	15	0,93
20	15,8	18	0,96
21	16,7	18	0,99
22	17,5	18	1,02
23	18,4	21	1,06
24	19,3	21	1,09
25	20,1	21	1,12
26	21,0	21	1,15
27	21,8	24	1,18
28	22,7	24	1,22
29	23,6	24	1,25
30	24,4	27	1,28
31	25,3	27	1,31
32	26,2	27	1,34
33	27,0	30	1,38
34	27,9	30	1,41
35	28,7	30	1,44
36	29,6	30	1,47
37	30,5	33	1,50
38	*31,3*	*33*	*1,54*
39	*32,2*	*33*	*1,57*
40	*33,0*	*36*	*1,60*
41	*33,9*	*36*	*1,63*
42	*34,8*	*36*	*1,66*
43	*35,6*	*36*	*1,70*

EAD-table for Open-Circuit Nitrox with 36 % O_2

(Dives should not be planned to depths indicated by italics)

Depth (metres)	EAD (metres)	Use table (metres)	pO_2 (Bar)
13	8,6	9	0,83
14	9,4	12	0,86
15	10,3	12	0,90
16	11,1	12	0,94
17	11,9	12	0,97
18	12,7	15	1,01
19	13,5	15	1,04
20	14,3	15	1,08
21	15,1	18	1,12
22	15,9	18	1,15
23	16,7	18	1,19
24	17,5	18	1,22
25	18,4	21	1,26
26	19,2	21	1,30
27	20,0	21	1,33
28	20,8	21	1,37
29	21,6	24	1,40
30	22,4	24	1,44
31	23,2	24	1,48
32	*24,0*	*27*	*1,51*
33	*24,8*	*27*	*1,55*
34	*25,6*	*27*	*1,58*
35	*26,5*	*27*	*1,62*
36	*27,3*	*30*	*1,66*
37	*28,1*	*30*	*1,69*
38	*28,9*	*30*	*1,73*
39	*29,7*	*30*	*1,76*

EAD-table for Open-Circuit Nitrox with 40 % O_2

(Dives should not be planned to depths indicated by italics)

Depth (metres)	EAD (metres)	Use table (metres)	pO_2 (Bar)
15	9,0	9	1,00
16	9,7	12	1,04
17	10,5	12	1,08
18	11,3	12	1,12
19	12,0	15	1,16
20	12,8	15	1,20
21	13,5	15	1,24
22	14,3	15	1,28
23	15,1	18	1,32
24	15,8	18	1,36
25	16,6	18	1,40
26	17,3	18	1,44
27	18,1	21	1,48
28	*18,9*	*21*	*1,52*
29	*19,6*	*21*	*1,56*
30	*20,4*	*21*	*1,60*
31	*21,1*	*24*	*1,64*
32	*21,9*	*24*	*1,68*
33	*22,7*	*24*	*1,72*
34	*23,4*	*24*	*1,76*
35	*24,2*	*27*	*1,80*

Surface Decompression Table Using Oxygen

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)			O_2 at 15 and 12m in chamber (min)	Total decomp. time (min.)	Repetitive group
		18	15	12			
15 metres	130	–	–	–	15	22	Z
	170	–	–	–	30	37	Z
	180	–	–	–	45	57	Z
	200	–	–	–	45	57	Z
	240	–	–	–	60	72	
	270 *	–	–	–	75	92	
18 metres	90	–	–	–	15	22	O
	120	–	–	–	30	37	Z
	140	–	–	–	45	57	Z
	170	–	–	–	60	72	
	200	–	–	–	75	92	
	220	–	–	–	90	107	
	240 *	–	–	–	105	127	
21 metres	70	–	–	–	15	22	N
	90	–	–	–	30	37	Z
	110	–	–	–	45	57	Z
	130	–	–	–	60	72	Z
	150	–	–	–	75	92	
	170	–	–	–	90	107	
	190 *	–	–	–	105	127	

Surface Decompression Table Using Oxygen

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)			O_2 at 15 and 12m in chamber (min)	Total decomp. time (min.)	Repetitive group
		18	15	12			
24 metres	55	–	–	–	15	23	M
	70	–	–	–	30	37	O
	90	–	–	–	45	57	Z
	110	–	–	–	60	72	Z
	120	–	–	–	75	92	
	130	–	–	–	90	107	
	150 *	–	–	–	105	127	

27 metres	45	–	–	–	15	24	M
	60	–	–	–	30	38	O
	70	–	–	–	45	58	Z
	90	–	–	–	60	73	Z
	100	–	–	–	75	93	
	110	–	–	–	90	108	
	130 *	–	–	5	105	133	

Surface Decompression Table Using Oxygen

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)			O_2 at 15 and 12m in chamber (min)	Total decomp. time (min.)	Repetitive group
		18	15	12			
30 metres	35	–	–	–	15	23	L
	50	–	–	–	30	38	O
	60	–	–	–	45	58	Z
	70	–	–	–	60	73	Z
	90	–	–	2	75	95	
	100	–	–	9	90	117	
	110 *	–	–	14	105	142	

33 metres	30	–	–	–	15	24	K
	40	–	–	–	30	38	N
	45	–	–	–	30	38	O
	55	–	–	–	45	58	Z
	60	–	–	–	60	73	Z
	80	–	–	9	75	102	
	100 *	–	–	25	105	153	

36 metres	30	–	–	–	15	24	L
	35	–	–	–	30	39	N
	40	–	–	–	30	39	O
	50	–	–	–	45	59	Z
	60	–	–	–	60	74	Z
	70	–	–	13	75	133	
	80	–	–	24	90	137	
	90 *	–	7	26	105	161	

Surface Decompression Table Using Oxygen

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)			O_2 at 15 and 12m in chamber (min)	Total decomp. time (min.)	Repetitive group
		18	15	12			
39 metres	25	–	–	–	15	24	K
	30	–	–	–	30	39	M
	35	–	–	–	30	39	O
	45	–	–	1	45	60	Z
	55	–	–	4	60	78	Z
	60	–	–	12	75	106	Z
	70	–	1	26	90	136	
	80 *	–	12	26	105	167	

42 metres	20	–	–	–	15	25	J
	30	–	–	–	30	39	N
	40	–	–	4	45	63	Z
	50	–	–	8	60	82	Z
	55	–	1	15	75	110	Z
	60	–	2	23	90	134	
	70 *	–	14	25	105	168	

45 metres	20	–	–	–	15	25	K
	25	–	–	4	30	44	M
	35	–	–	6	45	66	Z
	45	–	3	8	60	85	Z
	50	–	4	14	75	112	Z
	60 *	–	11	26	90	146	

Surface Decompression Table Using Oxygen

Depth not deeper than	Max. bottom time (min.)	Time at stop depth (min.)			O_2 at 15 and 12m in chamber (min)	Total decomp. time (min.)	Repetitive group
		18	15	12			
48 metres	20	–	–	1	15	26	L
	25	–	–	4	30	44	N
	35	–	4	6	45	70	Z
	40	–	6	6	60	87	Z
	45	2	5	11	75	112	Z
	55 *	3	11	26	90	149	
	60 *	6	17	25	105	177	

51 metres	15	–	–	–	–	15	25	J
	20	–	–	–	3	30	43	M
	25	–	–	1	7	30	48	O
	30	–	–	5	7	45	72	Z
	35	–	2	6	6	60	89	Z
	45	–	5	7	16	75	123	Z
	50 *	1	5	11	23	90	149	
	55 *	2	7	16	26	105	180	

Prevention of Decompression Illness

1. **Decompression.** Any ascent from the bottom to the surface entails decompression, in the term's true sense of reducing the ambient pressure. However, in diving terminology it is most common to reserve this term for the required stop time at the staged decompression stops. Hence, the term 'no-decompression dive', strictly speaking an oxymoron, is being used to denote a dive that allows a direct ascent to the surface without stops.

2. **Table Safety.** A safe table is one that, when used correctly, has proven successful in terms of a low DCI incidence. Still, we must keep in mind that no table guarantees a 100 % success for all divers and all exposures even if the procedures are closely adhered to.

3. **Factors increasing the risk for decompression illness.** The tables address two parameters only, namely time and depth. We know that several other factors play a significant role in determining the decompression obligation. By being aware of these factors we may use dive tables more wisely to plan and conduct safer dives. This chapter describes such factors that diving supervisors and divers should be aware of. If you comply with the recommendations in this chapter you may further reduce the risk for decompression illness, based on the diver's individual factors and the characteristics of the dive.

4. **Adjustment of decompression.** If there are circumstances increasing the risk for decompression illness, the decompression should be more conservative than prescribed by the tables. Especially this is true if multiple risk increasing factors are present and for dives with bottom times bordering the maximum allowed bottom time. In such cases the standard air decompression tables should be used more conservatively by decompressing according to a table time one or two steps longer than otherwise. For $SurDO_2$ dives, the oxygen breathing time in chamber should be extended as detailed below.

5. **Physical work** is probably the one factor, in addition to time and depth, that has the largest influence on decompression requirement. Increased work causes an increase in blood circulation which leads to faster uptake of gas in the tissues. The sensation of breathlessness during part of the dive is a good indicator of the physical strain of the dive.

6. **Individual factors.** Most divers and hyperbaric professionals assume that age, obesity and a poor physical fitness all contribute to an increased risk of DCI. However, research in this field is not conclusive. We are still confident that these factors play a role, especially the age and obesity factors. Unfortunately there is no published research indicating the magnitude of the extra risk. Until recently it was believed that women were more susceptible to DCI than men, but this has not been scientifically justified. Dive tables were originally being tested by young and fit military personnel, yet practice has shown that the tables provide good safety for most civilian divers as well. We recommend that divers who are overweight (BMI exceeding 30), older (above 50 years) or in poor physical fitness (not exercising regularly) to add a safety margin.

7. **Cold stress.** Typically, a diver will stay relatively warm during the bottom phase of a dive due to the work load. Then he may become cold during the subsequent inactive decompression phase. A cold decompression is less effective since the peripheral blood circulation is impaired. This will increase the risk for decompression illness.

8. **Recommended adjustment of decompression for standard air decompression dives.** To simplify the assessment of the individual risk factors, the table below may be used.

Score Risk factor	**1**	**2**	**3**
Work load	Low	Medium	High
Thermal comfort during decompression	Neutral/warm	Cold	
Individual factors Age > 50 BMI > 30 Sedentary	0-1 individual factors	2-3 individual factors	

By adding the scores for the various groups of risk factors you will achieve a total score ranging 3 to 7. The highest score will be achieved with a dive with a high work load, where the diver has been cold during decompression and has 2 or 3 of the individual risk factors. For score 5 we recommend that the decompression is adjusted according to a bottom time one step longer than the required. For scores 6 and 7 we recommend decompression according to a bottom time two steps longer than prescribed.

9. **Adjustment of table bottom times with SurDO$_2$.** Thermal comfort is not considered a risk factor given the fact that decompression mainly takes place in the recompression chamber.

Score Risk factor	**1**	**2**	**3**
Work load	Low	Medium	High
Individual factors Age > 50 BMI > 30 Sedentary	0-1 individual factors	2-3 individual factors	

The total score will range 2 to 5. We recommend the addition of 15 min of extra oxygen breathing time on 12m with score 4 or 5.

10. **Complying with the recommendations in this chapter.** We recommend that the decompression adjustments listed in this chapter should be followed to reduce the risk of DCI. We nevertheless consider that lack of compliance with the recommendations should not be considered a formal violation or "non-compliance". The reason for this is that a number of the factors are subjective (individual appreciation of work load and cold) and that they cannot be interpreted consistently. In addition it is difficult to ascertain the effect these factors have on the DCI risk. Thirdly it is not always possible to know in advance the extent of work load and thermal comfort during the decompression phase while planning the dive. Please note that the Repetitive Group Designator should not be changed even if decompression is prolonged one or two steps as a precautionary measure.

11. **Repetitive diving and diving for several consecutive days** increases the risk of DCI, even when the diver adheres to the tables. Different restrictions and recommendations apply to standard table dives and to the surface decompression dives. Please consult the relevant chapters.

12. **Acclimatization.** We have indications that repeated diving to the same depth over a long period of time actually **reduces** the susceptibility to DCI. This phenomenon is called 'acclimatization'. This would seem to conflict with the risk of accumulation covered in the previous paragraph. Acclimatization develops gradually over a couple of weeks and will be lost after a period without diving. Experience indicates that it is a good idea to avoid maximum bottom times the first day following a period of not diving.

13. **Fluid balance.** The elimination of inert gas relies on a proper blood flow, which in turn relies on a proper fluid balance. Sufficient intake of water or mineral water prevents DCI. Dehydration may be caused by illness, a hangover or simply by an inadequate fluid intake. Whatever the cause, dehydration will increase a diver's susceptibility to DCI. Some divers may tend to refrain from drinking prior to a dive to avoid the urinary discomfort during the dive. In fact, the restrictions to pass water represent a major constraint to the planning of long dives. Still, it is not a good idea to start a dive dehydrated and increase the risk of DCI. Avoid coffee, tea (and of course alcohol!) before diving. With $SurDO_2$ diving the diver should drink before, during and after the chamber exposure. A rule of thumb is to drink sufficient to pass clear urine.

14. **Tobacco.** All tobacco product, both those that are being smoked and "snus"/chewing tobacco should be avoided both before and directly after a dive, because the nicotine and the carbon monoxide have negative influence on gas exchange and blood circulation.

15. **Alcohol, drugs and medication.** It should go without saying that diving under the influence of alcohol poses a multitude of risk factors. Among these are poor judgement, impaired co-ordination, exacerbation of nitrogen narcosis and the masking of DCI symptoms. Alcohol will typically induce dehydration of the body and this is very likely to increase the risk of DCI. In a state of dehydration, blood will flow sluggishly and the elimination of nitrogen will suffer. We advise against diving for at least 8 hours after alcoholic drinks have been consumed. Any other drug or medication that causes drowsiness and impaired judgement is also incompatible with safe diving.

16 **'Patent Foramen Ovale'** (PFO) is an incomplete closure of the septum separating the heart's two upper chambers: the atria. This is a minor congenital defect found in about 30 % of the population. There are rarely any symptoms or consequences of this defect in daily life but in divers it raises the risk of DCI by a factor of 4-5. We currently do not advise routine screening for PFO but divers who have suffered from otherwise unexplained DCI are often tested during the medical check after the recompression treatment.

17. **Other Factors.** Even a person's diet may make a difference. Some research indicates the beneficial effect of cod liver oil and other poly-unsaturated fatty acids but this remains to be verified. Others claim that a history of musculo-skeletal damage seems to increase the risk. Last but not least, the incidence of DCI seems to be higher in the afternoon than in the morning, possibly indicating a hormonal effect that varies with the circadian rhythm. None of these claims have been substantiated, yet this is no reason to ignore them.

18. **The effects of physical activity during the decompression** are disputed. We believe in the benefit of light activities throughout the decompression phase, as opposed to the extremes of static inactivity or strenuous work. Avoid static loads or postures that restrict the free circulation of blood to any part of the body. For instance, do not grab the decompression line with one hand and keep that grip through the entire decompression and do not cross your legs while decompressing in a chamber. Further, it is advised to avoid strenuous activities for three hours after the dive.

19. **Repetitive depth excursions** (saw-tooth profile) during a dive should be avoided since it promotes the formation of bubbles. The risk will increase with depth and exposure time. Further, a saw-tooth profile may cause DCI even when the total exposure (time and depth) is well within the no-decompression range. To limit the number of ascents it is a good idea to use a line or other means to lower tools to the diver rather than calling the diver up to collect them. One should consider the use of a dive computer as an additional measure for dives expected to include repetitive depth excursions.

20. **Depth Profile.** The tables are designed to provide a reasonable degree of safety for dives to a given depth for the maximum stated time. Whenever the depth varies it is preferable to do the deeper part first since this will further provide an increased safety margin against DCI.

21. **Safety Stop.** Even when a diver observes the correct ascent rate it is always a good idea to include a safety stop at 5 m for 3 min for no-decompression dives exceeding 9 m. However, omitting a safety stop should not be considered a violation of these tables. Further, we advise that the diver makes a brief stop to check the time half-way through the ascent. Then, if he finds himself ahead of schedule he can pause until back on schedule. For surface controlled dives the tender will keep track of the time and will instruct the diver to stop while he checks the ascent rate.

22. **Deep Stops.** The ascent rate constitutes an important element of the decompression procedure. Data suggest that overly fast ascents promote neurological DCI, especially on deep dives. Hence, numerous divers all over the world have adopted the practice of including an extra, deep stop. The exact depth and time of these stops has not been standardized. Usually it involves a stop of 1–2 min at half the maximum depth or half-way between the maximum depth and the first mandatory stop. We advocate the use of deep stops whenever there is an indication for a more conservative decompression. If so, make a short stop approximately half-way to the surface. This stop should be included in the bottom time.

23. **Omitted Decompression.** Should a ‘low-on-air’ situation or other emergency force the diver to skip part of the decompression he should skip the shallower part. In other words, follow the table until you have to abort rather than speeding up the ascent or omitting deeper stops. Also see the chapter Emergency Procedures.

24. **Surge** represents a nuisance and a hazard, especially at shallow stops. The diver may suffer motion sickness; he may get bumped against the hull of the vessel and even experience a pulmonary barotrauma. Decompression dives should be avoided in such conditions, especially when air is the only available breathing gas. Nitrox provides the option of using a deeper stop profile according to the Equivalent Air Depth principle. However, provided logistics and training allow the option of using the surface decompression techniques this will be the safest approach. Should a diver using the standard air table be exposed to heavy surge while decompressing his best option will be to do the 3 m stop time at 6 m, thus avoiding the stronger wave action close to the surface.

25. **Oxygen Breathing at Surface** is recommended whenever there is reason to suspect a higher than normal risk of DCI and no other prescribed action applies to the situation. In practice this means an incident or conditions that is believed to promote DCI. In this situation, a period of 20 min oxygen breathing shortly after the dive is a worthwhile safety measure.

26. **Chamber Oxygen Breathing.** Hyperbaric oxygen therapy is more efficient than surface breathing and is preferred whenever an oxygen capable chamber is available. Recompress to 12 m for a maximum of two 30 min oxygen periods, each followed by a 5 min air break. Decompress on oxygen at a rate of 1 m/min. While prophylactic oxygen therapy is a useful tool it should not be used to justify a casual approach to decompression obligation, omitted decompression or DCI. One should never use post-dive oxygen breathing as part of a pre-planned or standard procedure.

27. **UK limitation on bottom time.** The British Health and Safety Executive (HSE) recommends the bottom time limits listed below in its' 'Approved Code of Practice'. Profiles that are not allowed according to UK bottom time restrictions are listed below the bold horizontal line in the standard and $SurDO_2$ tables. Such dives are not approved in Norwegian petroleum related diving (see appropriate chapter for details on this matter). There is a distinction made between 'Transfer Under Pressure' (TUP) and other decompression techniques such as in-water decompression or $SurDO_2$ (non-TUP). The TUP protocol entails the transfer of the diver in a pressurized diving bell. The bell is hoisted to the surface and subsequently mated to a topside chamber. The diver then moves from the bell to the chamber and decompresses according to the $SurDO_2$ protocol. TUP diving has presently (2017) not been used in Norway.

Maximum depth in metres	Maximum Bottom Time	
	TUP	Non-TUP
0-12	240	240
15	240	180
18	180	120
21	180	90
24	180	70
27	130	60
30	110	50

Maximum depth in metres	Maximum Bottom Time	
	TUP	Non-TUP
33	95	40
36	85	35
39	75	30
42	65	30
45	60	25
48	55	25
51	50	20

Deep Chamber Dives

1. Divers of the Royal Norwegian Navy have traditionally been exposed to deep, simulated dives to 60 or 90 m to demonstrate the effects of nitrogen narcosis in a safe, controlled and supervised environment. Further, such exposures could be used to increase tolerance to nitrogen narcosis. The effect of the suggested increased tolerance to nitrogen narcosis is disputed and is, at best, limited in duration and attenuated during the course of a few weeks.

2. Deep simulated dives, particularly challenges to 90 m, should be limited to clearly identified needs. Supervision and responsibility should be managed by personnel with sufficient experience and background.

3. The procedures have been designed to make such pressure exposures as safe as possible. The procedures are based on modified US Navy Diving Manual Rev 7. The procedures require:

   - Rate of descent (compression) 15 m/min
   - Rate of ascent (decompression) to first stop 10 m/min
   - Oxygen (O_2) to be breathed from 12 m surface
   - The diver shall breathe chamber atmosphere for 5 min for every 30 min of O_2. This time should be added to the O_2 breathing time indicated in the table below. Time at depths exceeding 6 m should be complied with, i.e. any additional air breathing should be added to the time spent at 6m. Such additional air breaks should not be allowed to exceed 15 min.

   The ascent time from bottom to the first decompression stop is not included in the stop time at the deepest stop. For the subsequent stops, the ascent time is included in the stop time for the shallower stops. Total decompression time listed in the tables include ascent time to the deepest top, air breaks and the time from 6m to surface. The ascent time between the stops and time from 6m to surface, is 1 min.

4. None of the simulated dives should be repetitive. Neither is a repetitive dive allowed after these exposures. The diver should not fly nor dive for 24h after finished deep chamber dive.

Depth not to exceed	Bottom time max.	Stop depths and time at the stops in min			Total decomp. time
		12 m	9 m	6 m	
60 metres	**12** min.	5	5	20	36 minutes
		min. breathing oxygen			

Depth not to exceed	Bottom time max.	Stop depths and time at the stops in min.							Total decomp. time
		24m	21m	18m	15m	12m	9m	6m	
90 metres	**12** min.	1	4	5	5	10	10	30	78 minutes
		min. breathing air				min. breathing oxygen			

Procedures in the event of an uncontrolled ascent

1. **An uncontrolled ascent requires prompt and decisive measures**, whether DCI is confirmed or not. The action being taken will depend on the location and the available resources. We advise all dive teams, professional as well as recreational, to bring a surface oxygen kit to any dive site. The capacity of the kit should be sufficient for 30 min administration of oxygen and preferably 60 min. For dives planned with decompression stops, a chamber should be available at the dive site or in the immediate vicinity.

2. **Uncontrolled ascent – oxygen on-site and chamber available for decompression dives:**
   - The diver develops symptoms of DCI: Recompress with Treatment Table 6 (TT 6). Contact the emergency medical dispatch service (113) and notify a diving accident.
   - The dive is a SurDO_2 dive: Recompress as per Treatment Table 5 (TT 5). For other dives, act in agreement with the bullets listed below.
   - The bottom time allows direct ascent to surface: If the diver is healthy and equipment OK complete a safety stop. Breathe oxygen on the surface for 30 min.
   - Omitted in-water decompression of 15 min and more: Recompress with TT 5.
   - Omitted decompression at a staged decompression stop or working depth on a standard table decompression dive, with 10 min or less omitted decompression: Provided the diver remains in good shape and his equipment is operational he should descend immediately and resume the decompression. When finished he should breathe oxygen on the surface for 30 min. Should the diver be unable to descend he should be compressed to a depth of 12 m in a chamber. After two 20 min oxygen periods, each followed by a 5 min air break he will decompress at a rate of 1 m/min while breathing oxygen.

3. **Chamber and/or oxygen not available on-site.** Staged decompression dives should not be conducted without the proper logistics. Nevertheless, for various reasons, an incident may take place under these circumstances. While it is impossible to devise proper procedures for every combination of mishap and deficient planning we still have a few suggestions. Attempts to make the best of a bad situation come with a high degree of uncertainty. If a decision for in-water recompression is taken it is crucial that the diver descends as soon as possible.

4. **Procedure: Omitted decompression or uncontrolled ascent in the absence of a recompression chamber on-site.**
   - The diver develops symptoms of DCI: Provide surface oxygen breathing. Contact emergency medical dispatch service (113), notify diving accident.
   - Ascent from decompression stop: Provided the diver is not injured and his equipment is in working order he should descend again and complete his decompression. Once he is back on the surface oxygen should be administered for 30 min if available. In case the diver is unable to descend to complete his decompression he should start breathing oxygen immediately and continue doing so for 30 min.
   - Ascent from the bottom / work depth – no-stop limit not exceeded: Descend to 5 m and complete a safety stop. Breathes oxygen for 30 min at surface. If oxygen is unavailable call diving physician.
   - Ascent from the bottom / work depth – no-stop limit exceeded: Diver's fitness and dive gear permitting, the diver should descend to the deepest staged decompression stop and complete decompression according to a schedule one bottom time longer than ordinary required. Breathe oxygen for 30 min at surface. If oxygen is unavailable call diving physician.

5. **In-water Recompression?** There is no consensus on how to best manage a case of DCI when neither oxygen nor an on-site chamber is available. Some will recommend in-water recompression, even when air is the only available breathing gas. In-water recompression remains a very controversial alternative and most diving medical experts oppose it. We choose to advise against in-water recompression for the following reasons:
   - The additional hyperbaric exposure will cause more nitrogen to be acquired, possibly exacerbating the problem when the diver surfaces for the second time.
   - It is hard to monitor a person under water and to take measures should his condition deteriorate.
   - The diver risks severe hypothermia.
   - The supply of breathing gas is likely to be limited.
   - Bad weather and wave action may create dangerous situations.

   It must be noted however, that some groups diving in remote areas with limited logistics have used in-water recompression successfully.

6. Despite our doubts and concerns we have chosen to present a standardized protocol for in-water recompression if such a procedure should be used. A standardized procedure may help reduce the risk of complications. For instance, the choice of an excessive recompression depth or the choice of a second inadequate decompression profile may easily make a bad situation worse. One point to keep in mind is that the success of in-water recompression is heavily dependent on getting back under pressure quickly – the longer the time from the onset of symptoms until the diver is recompressed the lower the probability of success.

7. Prerequisites for considering in-water recompression:
   - A sufficient amount of breathing gas to complete the treatment
   - A sufficient thermal protection for the exposure
   - The diver must be fit for the exposure, physically as well as psychologically
   - Reasonable sea state and weather conditions
   - Recompression should start immediately
   - Diving physician should be contacted and medical evacuation requested.

   Preferably the area's depth and bottom topography should allow for the patient to rest on the bottom.

8. The following plan may be used:
   - Descend to 12 m for 30 min
   - Decompress by spending 10 min at each metre, up to and including the 3-metre stop. Surface when the 3-metre stop is completed.

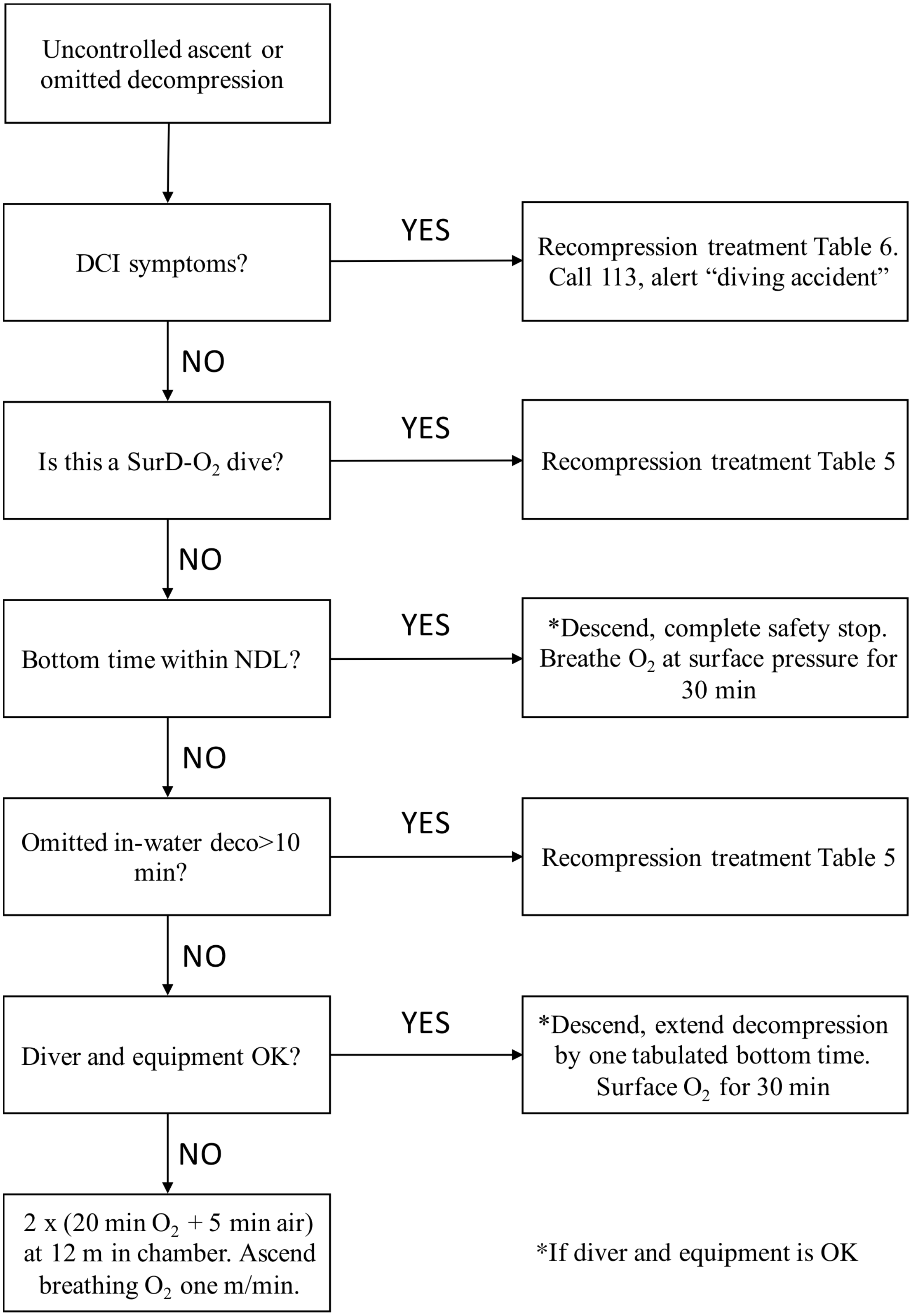
   Hence, the total time for this treatment schedule is two hours.

9. Light activity is recommended throughout the treatment, as opposed to hard work. The diver should be assisted when leaving the water, doffing his gear and putting on dry clothes. He should drink water and rest after the treatment. Even when the diver remains asymptomatic after the treatment he should seek hyperbaric chamber treatment as soon as possible. Also, whenever oxygen becomes available while the diver is being treated he should breathe oxygen as soon as he returns to the surface.

10. In-water recompression should certainly not be considered a standard treatment, or even an approved emergency treatment. Therefore, this controversial approach will not be covered in other chapters.

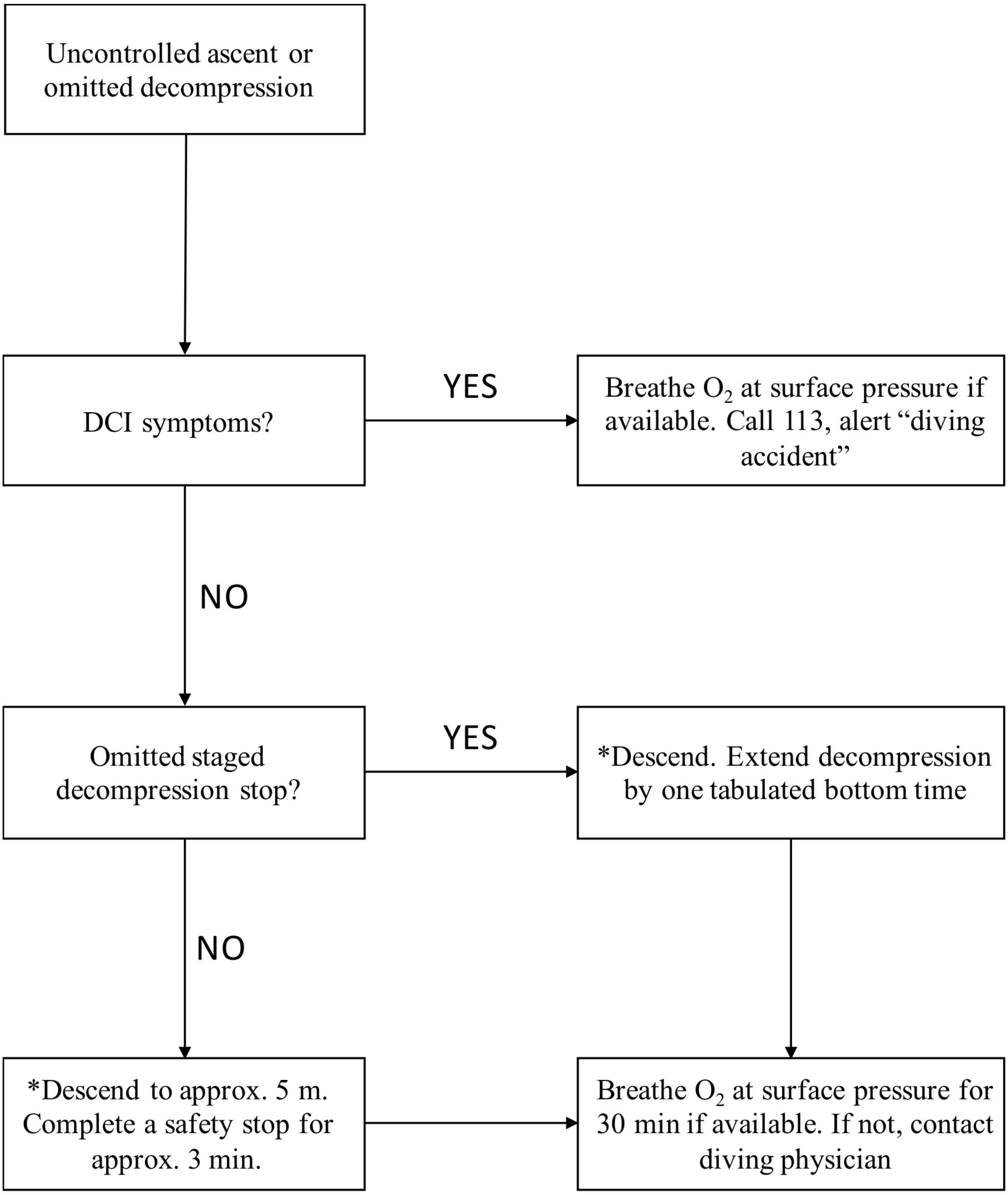
Emergency procedures – omitted decompression or uncontrolled ascent

Chamber and oxygen available on dive site



Emergency procedures – omitted decompression or uncontrolled ascent

Chamber and/or oxygen not available on dive site



*If diver and equipment is OK

Decompression Illness

1. **Decompression Illness (DCI)** is a term that covers a range of symptoms that arise when bubbles form in blood or tissue due to a too rapid decrease in ambient pressure. The definition of DCI itself and its proposed sub-categories remains somewhat unclear and controversial. The term 'decompression illness' is typically used to cover decompression sickness (DCS) as well as Cerebral Arterial Gas Embolism (CAGE) and Arterial Gas Embolism (AGE).

2. The various diving communities have typically used '**the bends**' as the term for any kind of decompression sickness, especially when pain is involved. One may also run into combinations as 'skin bends' and 'cerebral bends'. We used to divide decompression sickness into these categories:
   - DCS type I – less serious case of decompression sickness
   - DCS type II – serious case of decompression sickness
   - CAGE (AGE) which is caused by lung barotrauma that discharges gas into the arterial bloodstream. This gas typically travels to the brain.

3. **The type I and type II discrimination** is no longer used since it created a lot of confusion. It is better to describe a case of DCI by referring to symptoms and the parts of the body that are involved – for instance, neurological DCI, skin involvement, joint pain/involvement etc.

4. **DCS is caused by the formation of gas bubbles** in the bloodstream and/or in the tissues. We used to believe that the blocking of blood flow was the primary mechanism. Today there is more focus on changes in blood chemistry and injurious chain reactions caused by the bubbles. Blood platelets and white blood cells will aggregate on foreign objects (such as bubbles) and the inner lining of the blood vessels is injured causing tissue swelling (oedema). This will further cause an inflammatory reaction. These secondary reactions may develop slowly. An afflicted diver may experience an apparent recovery after the onset of symptoms followed by deterioration a few hours later. The treatment response is best if hyperbaric therapy is initiated early. Thus, it is important to seek medical advice as soon as possible.

5. **The symptoms of DCS** may manifest themselves during the decompression or in rare cases as late as 24 hours after a dive. As a rule of thumb, about 50 % of the cases will appear within the first hour and about 90 % within 6 hours after the dive.

6. **Cases of DCS involving skin and lymph only** ('skin bends' and 'lymph bends) are the least serious kinds. The primary symptom of skin bends is itching, commonly associated with a transient rash. Skin bends seems to be more common after short and deep exposures rather than long and shallower ones. In most cases the itching will subside within the first 15 min post-dive. The aetiology of skin bends is believed to be the formation of subcutaneous gas bubbles. Mild cases with a temporary itching, burning sensation or a rash that resolves quickly will usually not warrant hyperbaric treatment. Persistent cases will need to be treated.

7. **Lymph involvement** implies the blocking of lymph nodes and lymph vessels. The lymph vessels constitute the tissues' drainage system for excess fluid that will ultimately be returned to the blood circulation. When parts of the lymph system get blocked the adjacent tissues will swell. Usually this affects arms and chest but sometimes the thighs or the lower part of the abdomen and the crotch are involved. Blue or purplish discolouration of the skin may be present (marbling). Severe cases of DCS involving the lymph system may cause dehydration and circulatory collapse. The diver may suffer from weakness, nausea, cold sweat and a rapid heart rate/pulse – the same symptoms of shock due to circulatory insufficiency. Lymph involvement seems to be more common in divers using the surface decompression techniques.

8. **Joint involvement** (the bends, pain only) may affect one or several joints. Most commonly affected are knees, hips, shoulders and elbows. Arms are involved more frequently than legs. Symptoms are typically strong, yet diffuse pain. The distribution is rarely symmetrical (not afflicting the corresponding joint of the opposite limb). The painful area is normally not tender and sensitive to touch since the pain stems from deep within. However, semi flexion of the joint tends to alleviate the pain. It is claimed that local physical compression of the affected area will alleviate pain, but this is not by supported scientifically.

9. **Gas bubbles trapped inside joint capsules** have traditionally been proposed as the cause of pain. This is unlikely to be correct. It is more plausible that the offending bubbles are located inside nerves, at the base of tendons or inside the bone marrow. Any case of DCS causing joint pain should be treated with recompression.

10. **'Serious' DCS** includes:
    - Neurological DCS that can be subdivided into cerebral DCS and spinal DCS.
    - DCI of the inner ear (vestibular and cochlear DCS).
    - Chokes

11. **Permanent Damage.** All experience indicates that serious DCS carries a great risk of permanent damage (sequela). There are indications that even less serious cases may also cause permanent damage. Thus, it is important that all members of the dive team are well versed in recognizing the various symptoms of DCS and the necessity for prompt action once DCS is suspected.

12. **Fatigue.** During the recent years there has been an increasing focus on post-dive fatigue. Fatigue may be the only apparent symptom of DCS and it is hard to distinguish between fatigue caused by decompression stress from other causes (e.g. a strenuous dive). When in doubt, contact a diving physician.

13. **Cerebral DCS** is caused by gas bubbles in the brain. The symptoms are many fold, depending on which part of the brain is affected. The most common symptoms are fatigue, headache, nausea, vertigo and balance disturbances. In serious cases vision, consciousness, muscle strength and sense of touch may be impaired. In cases leading to numbness or paralysis, one side of the body will typically be affected. These are the same kind of symptoms as those of a common stroke in the elderly.

14. **Spinal DCS** is caused by bubbles in the spinal cord. The most common symptoms are numbness or pins-and-needles affecting legs or arms. Usually only one leg or one arm is involved but a transverse paralysis is not uncommon. Spinal symptoms will never cause a total paralysis of one side of the body from head to toe, this being the distinctive characteristic of cerebral involvement. Some divers report chest pain as the first symptom. When spinal DCS causes paralysis the legs are most commonly affected. The paralysis may also impair bladder and bowel functions but these dysfunctions will tend to go unnoticed for a while.

15. **Vestibular and cochlear DCS** is caused by bubbles lodged in the inner ear in the organs sensing balance and hearing. The most common symptoms are vertigo, loss of balance, nausea/vomiting and occasionally hearing impairment or tinnitus. Vestibular involvement may also be caused by isobaric counter-diffusion – that is, the switch from a slowly diffusing breathing gas (e.g. air) to a faster diffusing one (e.g. helium) without increasing the ambient pressure.

16. **Chokes** is a rare but very serious condition. It takes place when the major blood vessels of the heart and lungs get clogged with copious amounts of bubbles. The most common symptoms are chest pain, coughing and laboured breathing. Cyanosis may result due to insufficient oxygenation. Chokes may result from gross violations of the decompression requirements as an 'explosive' decompression from great depths. Immediate recompression is required to avoid death from circulatory collapse.

Barotrauma

1. **Barotrauma** is a term that covers various injuries caused by the direct effect of a pressure differential. Any air-filled cavity of the body will be subject to pressure damage if it fails to communicate freely with the exterior during changes in ambient pressure. Pulmonary hyperinflation injury is the most serious kind of barotrauma. Luckily, this is a fairly uncommon occurrence. Far more common are the various barotraumas of descent affecting ears and the sinuses, commonly known as 'squeeze'.

2. **Pulmonary hyperinflation injury** (burst lung) may result from undue expansion and stretching as the air expands during an ascent. Normally a diver will exhale excess air automatically but a panic-stricken diver may tend to hold his breath during an emergency ascent. Some pulmonary conditions may weaken the strength and the elasticity of the lung tissue (thin-walled bullae) while others may increase the airway resistance and compromise the person's ability to exhale efficiently (asthma).

3. **Pulmonary hyperinflation injuries** can be divided in three categories:
   - Alveolar rupture
   - Mediastinal emphysema
   - Pneumothorax

   The common cause of all these injuries is stretching and rupture of the lung tissue with air entering into the chest cavity or into ruptured blood vessels. Air embolism may result as a secondary condition, in which case air that has entered the bloodstream will be transported to other parts of the body (mainly the brain).

4. **Alveolar rupture** means damage to the alveoli without any significant amount of air entering into the chest cavity. An x-ray will fail to detect any air outside the airways in this case. Whenever a diver suffers from air embolism (ref. para. 8) after a dive and there is no detectable lung damage we assume a case of alveolar rupture. One may experience weak or transient symptoms resembling those of pneumothorax (ref. para. 6) but in most cases there are no symptoms whatsoever. Alveolar rupture *per se* is innocuous and does not require treatment. However, any sign of air embolism warrants immediate hyperbaric treatment due to the danger of secondary effects.

5. **Mediastinal emphysema** takes place when air that has leaked through minor ruptures of the lung is collected in the central region of the chest cavity (mediastinum). This involves the region along the oesophagus, the trachea and around the heart. Moderate chest pain upon inspiration is the most common symptom of this condition. Coughing may be another symptom as well as a 'metallic' voice distortion due to pressure on the larynx or its associated nerves. The air being trapped may move upwards and reach subcutaneous regions of the throat and shoulder area. If so, the area involved will be swollen and feels like powdery snow when touched. Mediastinal and/or subcutaneous emphysema will usually not require surgery. Such patients are admitted to hospital for oxygen breathing as this will accelerate reabsorption of free gas.

6. **Pneumothorax** (collapsed lung) will result when the pleural membrane is stretched beyond its limits and ruptures. When the pleural membrane is punctured the negative pressure surrounding the lungs will be relieved and cause the lung to collapse. Luckily, in most cases there is not total but rather a partial collapse involving one or several lobes. The most common symptoms are chest pain upon inspiration, possibly including coughing. When pneumothorax is suspected the patient should be hospitalized for an X-ray test and further treatment. Minor cases will be treated by administration of oxygen to speed up the reabsorption of the air pocket. More severe cases are treated surgically by insertion of a tube connected to a suction unit. The negative pressure created will re-expand the collapsed part of the lung. A case of pneumothorax will **never** be treated with recompression since the condition may actually worsen during the ensuing decompression i.e. as gas in the plural space expands.

7. Theoretically, a case of pneumothorax may be complicated by a flap-valve effect of the rupture. If so, the flap opens upon each inspiration and closes upon expiration. This will lead to the air pocket growing in size each time the diver draws his breath. The condition is called tension pneumothorax and it can be life-threatening. The diver will suffer from growing chest pain, cough and shortness of breath. The skin will turn pale and bluish (cyanosis) due to lack of oxygen. The condition can be alleviated by puncturing the chest cavity with a cannula. Tension pneumothorax, while being potentially fatal, is extremely rare. The majority of cases with the above mentioned symptoms suffer from lung oedema rather than tension pneumothorax.

8. **Air embolism.** Cerebral arterial gas embolism, (CAGE) may result as a secondary complication to all of the lung injuries described above. Actually, in most cases the lung injury fails to be diagnosed unless the diver is being treated for air embolism. Whenever a lung rupture involves blood vessels, air may enter the bloodstream and be transported to other parts of the body. While this air may end up in any organ the most serious condition takes place when the air ends up in the brain. Symptoms will be manifest as soon as the diver surfaces. Usually they include headache, nausea, vertigo, visual disturbances or loss of consciousness. Partial or complete paralysis of one side of the body may also result. In practice, air embolism may be hard to distinguish from neurological DCS. However, while symptoms of air embolism will be evident upon surfacing DCS will usually take at least 5 min to develop. Further, air embolism does not relate to the exposure while the risk of DCS certainly does. The dive history will give a good indication and differentiation. In any event, it is largely of academic interest to try to distinguish between the two since first aid as well as proper treatment will be identical.

Treatment of Decompression Sickness and Air Embolism

1. Whenever a diving related injury is suspected medical personnel should be contacted as soon as possible. Immediately phone the national emergency dispatch service (Norway: 113) in all cases of suspected and verified cases of diving related injuries or illnesses. If there is uncertainty as to whether diving medical advice is needed, the duty diving physician at Haukeland University Hospital may be contacted, 24/7 at +47-55 36 17 00.

2. **Examination of the injured diver** should never be allowed to delay oxygen administration or hyperbaric treatment (see below). However, there will usually be time for assessment while one is awaiting transport or preparing the chamber. In any event, it is crucial to continuously monitor vital signs, i.e. the patient's breathing, pulse and state of consciousness. A patient whose level of consciousness is effected should be placed in the recovery position to secure open airways (head tilted slightly back).

3. **First Aid.** Patients suffering from decompression sickness or air embolism seek immediate hyperbaric treatment. However, while the patient awaits the ultimate treatment it is important that he receives oxygen and drinks enough water. It is recommended to log the patient's symptoms, including all possible changes over time and the details of preliminary treatment given. In the past various drugs used to be recommended (e.g. acetyl salicylic acid/"Aspirin"). Recent research indicates that such medication is ineffective, hence it is no longer recommended.

4. **Administration of oxygen** should start as soon as possible. We recommend demand valve systems rather than constant flow for two reasons – they ensure that 100 % oxygen is inspired and they conserve the limited supply of gas. Alternatively, systems with a reservoir bag may be used. Provide sufficient flow to keep the reservoir bag filled. Free flow systems without reservoir are less suited. When the only option is a non-reservoir constant flow system the flow selector should be set at 12 – 15 l/min. The administration of oxygen should be continuous until the patient reaches the hyperbaric facility since surface oxygen breathing carries no risk of oxygen seizures.

5. **Hydration.** Patients suffering from DCI tend to be dehydrated. Conscious patients should be offered something to drink and they will typically need at least one litre to restore their fluid balance. A practical indicator is to keep drinking until one produces colourless urine. Water, juice or any soft drink will be good choices while coffee, tea or alcoholic beverages should be avoided. Patients who are not fully conscious should not be offered anything to drink due to the risk of inhaling fluid. Intravenous fluid administration is the only safe way to hydrate semi-conscious patients.

6. **Preparing for Medevac.** The patient should bring his dive log, depth gauge and/or dive computer. Breathing gas cylinders will normally not go with the patient. But the valves should be closed to secure the remaining gas as a sample in case breathing gas contamination may be an issue. Then, if there is reason to suspect carbon monoxide poisoning this may be confirmed or ruled out by a subsequent analysis of the breathing gas. Another issue is whether the diver's buddy should accompany him to the hyperbaric facility; this should be assessed by the emergency dispatch service. The main rule is to include an asymptomatic buddy whenever both of them have violated the decompression tables. Conversely, when no procedures have been violated there is no reason to treat the buddy of a diver with DCI.

7. **Mode of Transport.** The choice of transport will depend on location, topography, the urgency of the situation and the available options. The persons in charge of the medevac, always including a diving physician, will make that decision in co-operation with the team's dive supervisor. Whenever air evacuation is chosen the altitude (or, cabin altitude when the aircraft is pressurized) should stay below 300 m (1000 ft). Under no circumstances should a diver suffering from DCI be taken above an altitude of 500 m (1,500 ft).

8. **The hyperbaric chamber** has to be of a dual lock design to allow the transfer of chamber attendants without decompressing the main compartment. Further, a treatment chamber needs an oxygen system with masks. It shall have an overboard dump to avoid expired oxygen in the chamber atmosphere; otherwise the oxygen level inside the chamber will rise and cause a fire hazard. Further, if the chamber is going to be used for Treatment Table 6A or 6He schedules it will have to be fitted with mixed gas BIBS lines (nitrox or heliox) in addition to the oxygen. Portable one man chambers are not suited for treating DCI.

9. **The Choice of Treatment Table (TT).** There used to be a multitude of treatment tables which caused the choice to be difficult and inconsistent. This was compounded by the fact that there were no absolute criteria. We now recommend that all DCS/gas embolism patients be recompressed to a depth of 18 m and start breathing oxygen. Then the diving physician will assess the situation and decide which further actions to take. Unless there are special complications the usual choice will be to complete TT 6.

10. **Life-threatening Symptoms.** By life-threatening symptoms we refer to serious symptoms manifesting shortly after a dive (within 10 min). For instance, a diver may surface unconscious or he may experience rapidly progressing paralyses. Even in such cases the first step will be to start a TT 6. If the condition deteriorates at a chamber depth of 18 m or the diver fails to improve after having spent 10-20 min at 18 m, further compression will be considered. If so, the alternatives are TT 6A or 6He, providing that the chamber has mixed gas supply. Any decision to utilize TT 6A or TT 6He should be referred to a diving physician since the risk of running into complications will be higher. Further, there is inconclusive evidence on the effectiveness of these schedules.

11. **Table Extensions.** Serious cases of DCI (neurological, vestibular) that do not resolve within the three first oxygen periods at 18 m may warrant an extension of TT 6. If so, a qualified diving physician may order additional oxygen periods at 18 m and/or at 9 m.

12. **Complications during Recompression Therapy.** The most usual complication is barotrauma leading to ear and sinus pain. This will rarely warrant any treatment beyond the administration of decongestant nasal spray and mild analgesics. A quite different complication is the risk of oxygen seizures during TT 6. This occurs in one out of one thousand treatments.

13. **Acute Oxygen Toxicity.** In case a patient suffers from oxygen seizures during the chamber treatment the immediate action is to remove the breathing mask. Then the diving physician in charge will decide how to proceed. As far as the treatment itself is concerned the odds for success are better if the original plan is followed. Still, the diving physician may advise against any further exposure to pure oxygen. Provided the treatment is resumed we recommend an anti-convulsant medication (such as Midazolam®, Stesolidl® or other brand) to prevent recurrent seizures. If medication is given by persons without appropriate medical training, the drugs should preferably be administered by nasal spray, alternatively suppositories or enema. When seizures occur at 18 m the oxygen treatment will usually be resumed at a shallower depth. Should it be impossible to consult the diving physician the oxygen treatment must be aborted. If so, enter TT 1 at 18 m and run this schedule to the surface. This will entail a remaining decompression time of 5 hrs, 51 min. Although a 'technically correct' procedure, this is not a good solution. Thus, we once again emphasize the importance of establishing and maintaining contact with a diving physician throughout the hyperbaric treatment.

14. **Failed Oxygen Supply.** Whenever the oxygen supply fails the patient will necessarily breathe chamber air at the current depth. Provided the oxygen supply is re-established within 15 min the oxygen breathing is resumed and the treatment schedule proceeds as planned, adding oxygen time to make up for the unintended break. If the oxygen supply cannot be re-established within 15 min the contingency plan is to switch to TT 1. If so, TT 1 will be entered at the current depth and followed to the surface.

15. **Atelectasis.** Oxygen breathing may cause small areas of the lung to collapse (atelectasis) if the ventilation of these areas is compromised by any reason. For all practical purposes, this is not a significant problem, but may cause short lasting chest pain when the areas are re-expanded during a deep inspiration. To avoid this, we advise a regular (every 5-10 min) a deep inspiration when breathing 100 % O2 during $SurDO_2$ or hyperbaric oxygen treatment.

16. **Chamber Attendant.** A chamber attendant should always accompany a patient during a hyperbaric treatment, mainly to be of assistance in case the patient convulses. In Norway there has recently been a focus on the risk of developing DCI when serving as a chamber attendant. The current procedures render this risk small, provided the guidelines are followed.

17. **Trailing treatments** are often required for DCI. Usually, this means one session each day or perhaps two sessions per day in serious cases. The total number of treatments will rarely exceed five or six. The efficiency of the various Treatment Tables is poorly documented and the differences seem to be small between the various alternatives. In Norway, HBO 14/90, 14/60 and TT 5 are the most commonly used choices. In any event, the selection of tables as well as the number of treatments will be decided by a diving physician.

18. **Treatment Table 1** is no longer recommended since the oxygen tables have proved to be far more effective. The main reason for including it is that it represents a contingency plan if the oxygen supply fails. For surface decompression this will imply entering table 1 at 12 m. The remaining time at 12 m may be adjusted by subtracting the time that has been spent at 12 m already. As soon as the diver has spent 30 min at 12 m, the time before switching to table 1 included, the chamber may be moved to 9 m. TT 1 may also be used as a contingency plan for hyperbaric treatment – in short, whenever oxygen breathing has to be discontinued for medical or logistical reasons.

19. **Treatment Table 5** is primarily used for cases of omitted decompression with no symptoms of DCI. If so, the chamber run will be considered as an operative procedure rather than being a treatment. Table 5 may also be used for follow-up treatment sessions or in special cases when the diagnosis is uncertain. Earlier it was common to recommend the use of TT 5 for less serious cases. Dive teams would then treat 'less serious' cases on-site without involving medical expertise. This is no longer recommended since cases that appear to be benign may very well include neurological involvement that goes undetected.

20. **Treatment Table 6** is the standard choice for all cases of decompression sickness and cerebral arterial gas embolism. If the patient does not respond well during the first oxygen period at 18 m one may switch to TT 6A or 6He.

21. **Treatment Table 6A** used to be the recommended choice for treating cerebral arterial gas embolism. However, research as well as experience indicate no significant advantage over TT 6 and the risk of complications is higher. Thus, we do not recommend the use of TT 6A unless a patient suffering severe DCI fails to respond during the first oxygen period of a table 6 treatment. TT 5A is suited for cases where one wants to finish a TT 6A run as quickly as possible, for instance in cases where decompression sickness or cerebral arterial gas embolism has been ruled out during the course of a treatment.

22. **Treatment Table 6He** is based on the experience of COMEX and the Israeli Navy. They claim that this table produces better results in treating neurological DCI but this remains to be verified. Opinions vary on when to use TT 6He – the primary indications are neurological DCI that does not respond to standard treatment and uncontrolled ascents from great depths, especially when helium is involved. A table 6He treatment should never be considered unless it is ordered by a qualified diving physician.

Oxygen Treatment of Non-Diving Related Disorders

1. **Hyperbaric Oxygen Treatment (HBO).** A multitude of conditions and injuries may benefit from oxygen administration at an elevated ambient pressure. In Norway, Haukeland University Hospital has the national responsibility for elective (planned) HBO treatment and provide such treatment in their hospital chambers. In addition the hospital provide multi-regional treatment capacity for acute HBO treatment. Similar emergency HBO-treatment is provided by hospitals in Tromsø and Oslo. However, some patients with non-diving related conditions are still being treated in civilian and Navy chambers that are not under the direct auspices of the hospital. For this reason we have chosen to include a presentation of the most commonly used treatment tables. It may serve as a reference for operative and technical personnel in charge of HBO treatment.

2. **Chamber Modifications.** Chambers that will be used for HBO treatment of non-divers may need modifications and adaptations. This should be worked out in co-operation with the hospital and the physicians to be in charge of the treatment. We will present some general guidelines.

3. **Oxygen Supply.** The chamber should be equipped with at least one extra outlet for oxygen inside. This should be fitted with a flow metre providing a range of 0-20 l/min and that allows connection to a bag ventilator (resuscitator). The patient's expiratory gas must be led out of the chamber. This requires a special set-up in connection with the exhaust (overboard dump).

4. **Medical suction** must be available to clean the airways of critically ill patients during the treatment. A compressed air driven ejector suction is best suited but a mechanical unit driven by a foot pump will work too.

5. **Medical Equipment.** Electrically powered medical equipment must be tested and approved for hyperbaric use to avoid fire and explosion hazards. The majority of equipment commonly used for diagnosis and treatment will work as intended when in the hyperbaric environment but anything involving closed, air-filled spaces may be destroyed or cause damage. Medical personnel planning to operate equipment inside the chamber must be aware of these issues. Some of the commonly used pieces of equipment that must be pressure compensated are the drip chamber of intravenous infusion kits, the cuff of a tracheal tube (The expansion bag in the lower part of the air tube) and the pressure cuff of infusion bags. These must all be equalized when the chamber pressure is adjusted – that is, addition of air during compression and venting of excess air during decompression.

6. **Hygiene and the Control of Contaminated Waste.** The risk of being exposed to body fluids (vomit, blood, urine, faecal matter) is increased during a chamber treatment. When disposable medical equipment such as syringes are employed these should be put in a plastic bottle after use. However, **do not cap the bottle** since this will cause pressure equalisation problems. A roll of paper towel, disposable gloves and a plastic bag for garbage are other useful paraphernalia. The chamber must be cleaned inside when the chamber treatment is finished. Use disposable gloves and remove any visible stains with a sheet of paper towel. Surfaces as the chamber floor, seats and bunks should be cleaned with standard household detergents. Areas that have been contaminated with body fluids, on the other hand, must be disinfected. Clean the areas in question with soap and water before applying any disinfectants. Take care to remove any soap residue since these may otherwise interfere with proper disinfection. 70 % ethanol or Virkon® is the best suited disinfectant but it may be hard to obtain. A good alternative is concentrated chlorine solutions (e.g. Klorin®) (1 cap of Klorin in 0.5l water). In any event, it is important to ventilate the chamber properly after disinfecting it to ensure clean, odourless air the when next the chamber is operated.

8. **Gas gangrene** is a soft tissue infection caused by the bacterium *Clostridium perfringens.* This bacterium is anaerobic, which means that it thrives in tissue lacking oxygen. It produces a toxin that destroys the damaged tissues further. Gas gangrene may result from traffic accidents with extensive crush injuries or from abdominal surgery. The treatment involves the administration of antibiotics, surgical removal of infected tissue and HBO. The most commonly used HBO treatment is repeated sessions according to the HBO 20/90 table – three treatments on the first day and then twice a day for the next two days, until the infection is controlled or seven chamber runs altogether.

9. **Carbon Monoxide Poisoning.** Carbon monoxide (CO) is a colourless and odourless gas that forms during the incomplete combustion. Common sources are fires and exhaust gas emissions from motor vehicles or other internal combustion engines. CO bonds to haemoglobin 250 times better than oxygen, which means that CO displaces and impairs the transport of oxygen. Even more important, CO will suppress normal cellular metabolism. Patients suffering from limited exposure to carbon monoxide will typically complain of fatigue, headache and nausea. In serious cases the patient may be unconscious and secondary complications may be myocardial infarction as well as respiratory arrest. There is a great risk of long term neurological injury in surviving patients, chiefly in the form of headache, fatigue and attention deficits. It is assumed that HBO reduces the risk of residual damage but opinions vary when it comes to less serious cases. Some advocate the use of normobaric oxygen administration for these. Haukeland University Hospital recommends (as per 2017) that pregnant patients with HbCO>20 or those being unconscious should be treated with one session of HBO table 20/90.

10. **HBO treatment of carbon monoxide poisoning** will usually be carried out according to the HBO 20/60 table. When a person breathes pure oxygen at a depth of 20 m the half-time of CO in the bloodstream is 20 min, as opposed to about 5 hours when air is being breathed at sea level pressure. Further, the high partial pressure of oxygen will cause a significant rise in the blood oxygen tension and this surplus of dissolved oxygen will be adequate to maintain vital functions, even when the haemoglobin transport has failed. HBO is also thought to limit or reverse various biochemical damage caused by the CO.

11. **Radiation damage to bony tissue** (osteoradionecrosis) may benefit from HBO. In particular, the improved healing of jawbone damage is well documented. Radiation damage is characterized by tissue rarefaction (necrosis), poor perfusion and chronic infections. HBO 14/90 or 14/60 are used to treat radiation damage, usually as a long series of chamber sessions (typically ~20). The benefit can probably be attributed to increased production of collagen which in turn leads to improved vascularisation – another benefit is an improvement in the tissues' ability to fight infections. Chronic bone infections (osteomyelitis), chronic wounds (especially foot lesions caused by diabetes) and transplants with impaired circulation may also benefit from HBO treatment. These conditions will be treated with the same tables as those for radiation damage.

EUROPEAN
RESUSCITATION
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Basic Life Support with the use of an Automated External Defibrillator (AED)

Check response

- Shake gently
- Ask loudly: "Are you all right?"

If unresponsive

- Open airway & check for breathing

If unresponsive and not breathing normally

- **Call 112, send someone to get an AED**

If breathing normally

Turn into recovery position

- Call 112
- Continue to assess that breathing remains normal

Start chest compressions immediately

- Place your hands in the centre of the chest
- Deliver 30 chest compressions:
  - Press firmly at least 5 cm but no more than 6 cm deep
  - Press at a rate of at least 100/min but no more than 120/min
- If trained and able combine chest compressions with ventillations otherwise continue with compression only CPR
  - Seal your lips around the mouth
  - Blow steadily until the chest rises
  - Give next breath when the chest falls
- Continue CPR 30 compressions to 2 ventilations

As soon as AED arrives
Switch on the AED & attach pads

- Follow the spoken/visual directions
- Attach one pad below the left armpit
- Attach the other pad below the right collar bone, next to the breastbone
- If more than one rescuer: do not interrupt CPR

If shock is indicated

- Stand clear and deliver shock
- Continue CPR

Follow AED instructions

Continue CPR unless you are certain the victim has recovered and starts to breathe normally.

www.erc.edu | info@erc.edu
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 Product reference: Poster_BLS_AutomatedExternalDefibrillator_Algorithm_ENG_20151001

Diagnostics

1. This chapter provides guidelines for diagnosis and first aid by non-medically trained personnel at the dive site. The information provided can greatly assist the diving physician to make the right decisions.

2. **Handling of an unconscious victim** has been described on the previous pages.

3. **Handling of a conscious patient.** The first thing you should do in your further examination is to get an overview of the medical history and learn this:

   - **Medical history.** Ask the patient whether he/she suffers from any chronic conditions and whether the current situation may be linked to previous incidents. Ask for diabetes, epilepsy and cardiac disease. Current or recent use of medication? There is no need to focus on details – the main point is to gain information on conditions that may be responsible for the incident.
   - **The case at hand.** Establish exactly what the patient was doing, focusing on type of work and dive profile. Obviously, when a diver suffers an external trauma the dive particulars are less significant – however, work load and profile are important facts whenever decompression illness is suspected. Obtain information to rule out or confirm external injuries, accidents under water, diving gear malfunction, high work load and strong currents. **Which** were the initial symptoms? **When** did they manifest? **How** did the symptoms develop? Try to obtain a precise timeline of events, the first appearance of symptoms and the further development of symptoms. By linking the onset of symptoms to the phase of the dive or incident during the dive one will be able to diagnose the case correctly and assess its severity.

4. **Are there signs of trauma?** Try to obtain as much information as possible and provide an accurate description of your findings. Do not try to make a diagnosis, since this will be the responsibility of professional medical personnel – your job is to provide the facts and observations upon which they will base their conclusions.

6. **Checklist.** The following list is meant as a guideline for the examination of diving-related injuries. It is less suited for general injuries caused by dynamic force as fractures, wounds and trauma, especially from point 6 onwards. Use your best judgement and include the tests that seem relevant. In any event, the first five tests will apply to any kind of injury. Take down your findings and pass the information on to the medevac personnel.

Examination checklist

No	Topic	Description	OK	
			Yes	No
1	Level of consciousness	Does the patient speak spontaneously and does he respond appropriately when spoken to? If not: Does he respond to pain as expected (withdrawal response), ineffective or not at all? ***Repeat this assessment every 5.-10. min until other instruction is given by health professionals.***		
2	Airways	If the diver doesn't respond when spoken to then ensure that the airways are open by extending the neck and protruding the cheek. Visually inspect the mouth for foreign bodies.		
3	Breathing/ respiration	Is the patient breathing? What is his breathing frequency, breathing depth and regularity? ***Repeat this examination every 5.-10. min until other instruction is given by health professionals.***		
4	Pulse (circulation)	Is there a pulse? Rate? Regular heart beat? Do you feel the pulse strongly? Weak? ***Repeat this examination every 5.-10. min until other instruction is given by health professionals.***		
5	External injuries	Wounds/lesions? Bleeding? Discolouration of skin/ bruises?		
6	Skin temperature and colour	May be hard to assess in the field, especially when the patient is wearing a dive suit.		
7	Rashes	If present, in which areas? Describe the distribution of the rash and its colour and pattern. Are areas of the skin raised or appear marbled? ('Marbling' shows as thin blue lines forming a pattern). Use your mobile telephone and take pictures, but avoid getting to close – the images frequently get to blurry then.		
8	Pain	Describe any pain and learn the exact location and extent of local pain. Is the pain made worse by applying external pressure?		

No	Topic	Description	OK	
			Yes	No
9	Joint pain	Make the patient move any affected joints. Ask the patient whether pain increase or diminish when the joint is flexed or held in certain positions. Will flexing of the joint cause more pain when you resist the movement? Ask the patient whether h has experienced any area tender for direct pressure and try to confirm this by touching/putting pressure on the affected point.		
10	Muscle strength	Check for normal muscle strength by making the patient extend and flex all limbs while you resist the movement (shoulders, elbow, wrist, hip, knee, ankle). Look for any differences in strength between opposing limbs. However, keep in mind that a person's right (or, dominant) arm tends to be somewhat stronger than the other.		
11	Speed	Have the patient beat his chest as quickly as possibly. Let him/her beat his thigh as quickly as possibly – alternating with the palm and back of the hand. You want to look for speed, equal performance and fluency of movement.		
12	Co-ordination	Have the patient close his eyes and then move one hand to touch the tip of his nose with his index finger. Also, make him extend his arms to each side and then aim to touch the tip of one index finger with the tip of the other. (A miss by up to 3-4 cm is acceptable). A similar co-ordination test may be performed by trying to make the heel touch the opposite leg with a smooth movement.		

No	Topic	Description	OK	
			Yes	No
13	Balance	Be prepared to support the patient so he doesn't fall during this examination! Let him stand upright, feet together, arms along the side, open eyes. Look for poor balance or unusual swaying and especially, a tendency to lean or to one side or topple. Repeat with closed eyes. Is he swaying significantly more with closed eyes? If in doubt repeat examination instructing the patient to put one foot in front of the other and arms crossed over the chest. Compare balance with open and closed eyes.		
14	Gait	Have the patient walk and turn with his eyes open and look for any usual gait or imbalance. Ask him to walk on his heels and then toes. Look for weakness. Check for proper balance by having him perform a 'military' 180 degrees turn.		
15	Skin sensitivity	Check for skin sensitivity by touching the patient in various areas of the feet, arms, body and face. Look for any differences in skin sensitivity of opposing areas (left versus right) and look for differences at various levels (head to toe). Ask the patient whether he can feel your touch and whether some areas seem to be numb.		
16	Vision	Do both pupils appear to be of similar size? Cover one eye and ask the patient whether he can see clearly (use a small object at 5-6 m distance); then cover the other eye and repeat the test. Check for diplopia (double vision) by asking the patient to follow your finger as you move them in a "H" pattern in front of him. Check for fluent, parallel eye movements as the patient fixes his eyes on the moving finger.		
17	Hearing	Lightly scrub two of your fingers outside the patient's ear, repeat at opposite side. Does he hear this approximately equal?		

No	Topic	Description	OK	
			Yes	No
18	Fistula-test	Only if the diver is complaining of vertigo, tinnitus or reduced hearing. Place yourself in front of him. Ask him to equalize carefully. Do the symptoms worsen? Can you observe uncontrolled or jerky eye movements (Nystagmus)?		

Write date, time and findings below. For serious accidents you should make a note of level of consciousness, pulse and respiratory rate every 5.-10. min below.

Selecting correct Treatment Table

Flowchart for treatment of Decompression Sickness and Arterial Gas Embolism

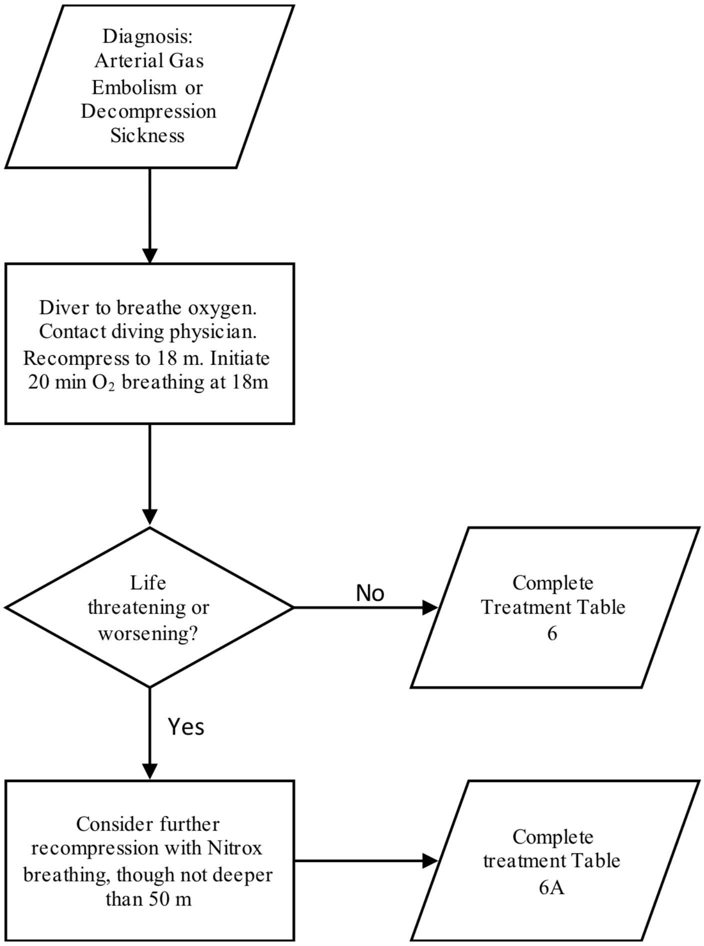
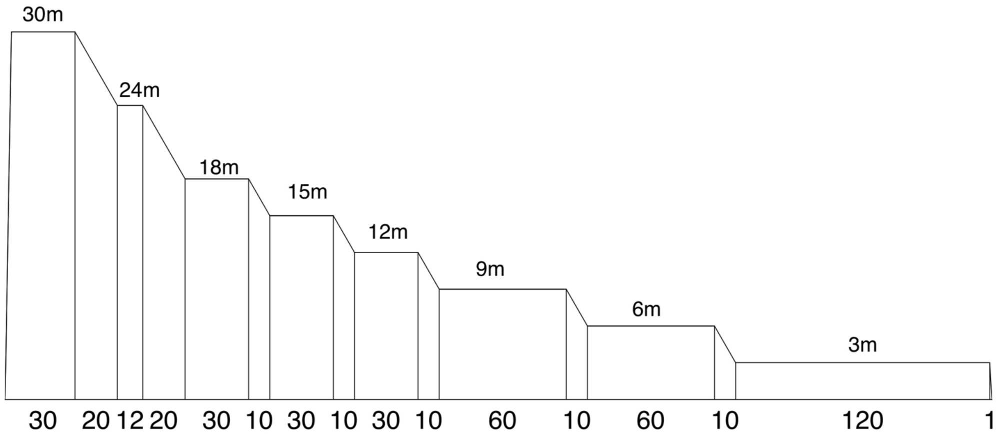


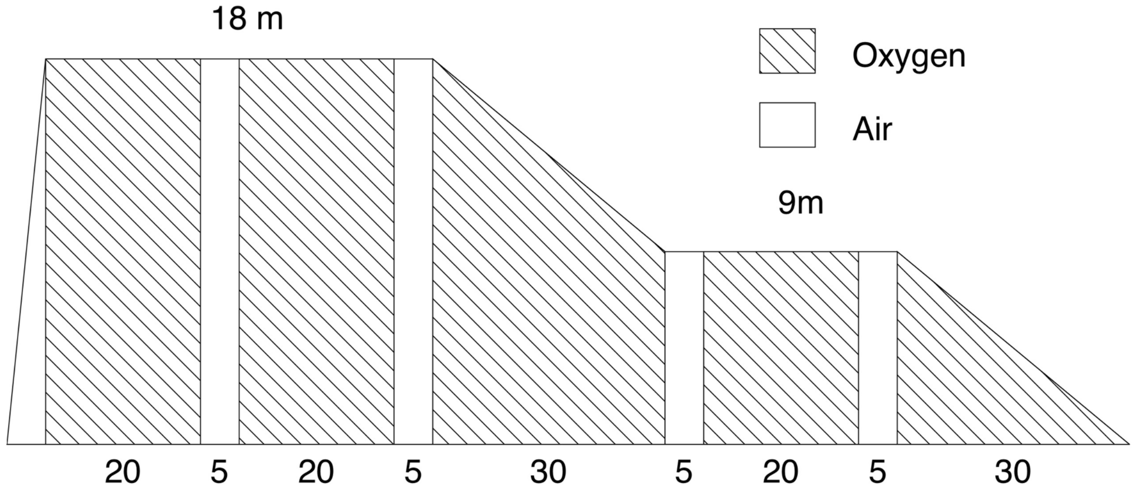
Table 1



Compression and decompression
Rate of compression at will. Time at 30 m includes time of descent. Decompression rate between stops is 0.3 m/min.
Patient
To breathe air during the treatment.
Chamber attendant
To breathe air during the treatment.
Extension
No extensions

Depth in metres	Time in minutes	Breathing gas	Running time h : min.
30	30	Air	0 : 30
30 - 24	20	Air	0 : 50
24	12	Air	1 : 02
24 - 18	20	Air	1 : 22
18	30	Air	1 : 52
18 - 15	10	Air	2 : 02
15	30	Air	2 : 32
15 - 12	10	Air	2 : 42
12	30	Air	3 : 12
12 - 9	10	Air	3 : 22
9	60	Air	4 : 22
9 - 6	10	Air	4 : 32
6	60	Air	5 : 32
6 - 3	10	Air	5 : 42
3	120	Air	7 : 42
3 - 0	1	Air	7 : 43

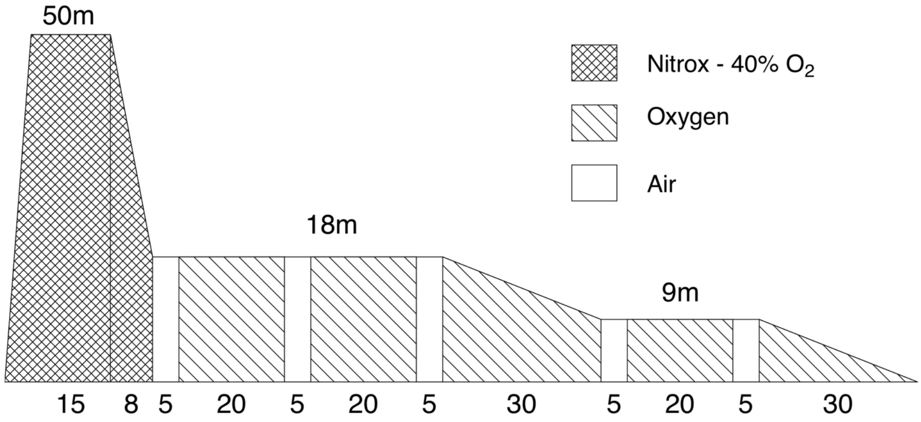
Table 5



Compression and decompression Rate of compression at will. Decompression rate 0.3 m/min.
Patient Breathing gas: Optional chamber gas or BIBS O_2 during compression. Time on O_2 running from arrival 18 m.
Chamber attendant Breathes O_2 on BIBS during decompression from 9 m to surface. If repetitive dive to breathe O_2 on BIBS from last O_2 breathing period identical to the patient.
Extensions A maximum of two additional O_2-periods at 9 m allowed.

Depth in metres	Time in minutes	Breathing gas	Running time h : min.
0 - 18	–	Air/O2	–
18	20	Oxygen	0 : 20
18	5	Air	0 : 25
18	20	Oxygen	0 : 45
18	5	Air	0 : 50
18 - 9	30	Oxygen	1 : 20
9	5	Air	1 : 25
9	20	Oxygen	1 : 45
9	5	Air	1 : 50
9 - 0	30	Oxygen	2 : 20

Table 5A



Compression and decompression

This treatment table is to be used on the order of a physician only.

Compression to 50 m should be rapid. Time at 50 m includes time for compression.

Decompression rate from 50 to 18 m, is 4 m/min. From 18 to 9 and from 9 to 0 the rate is 0.3 m/min.

Patient

To breathe Nitrox with 40 % O_2 and O_2 on BIBS as shown.

Chamber attendant

To breathe Nitrox 40 at 50 m and during decompression to 18 m. (No air breaks.)

To breathe O_2 on BIBS identical to the patient from the last O_2-breathing period at 9 m.

If repeated dive and/or extension of treatment table he should breathe O_2 on BIBS identical to the patient during decompression from 18 m and further on.

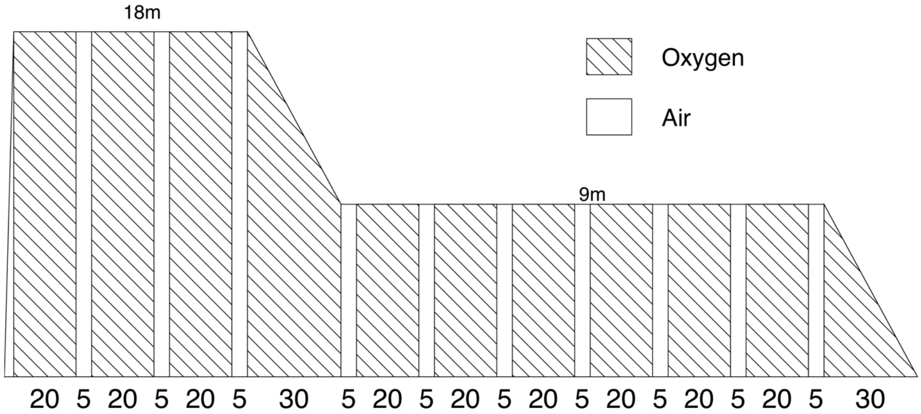
Extension

No extensions.

* If the breathing gas at 50 m is air, the decompression rate is 1 m/min, and there is no 5 min air stop on arrival 18 m.

Depth in metres	Time in minutes	Breathing gas	Running time h : min.
0 - 50	-	Nitrox	-
50	15	Nitrox	0 : 15
50 - 18	8 *	Nitrox	0 : 23
18	5	Air	0 : 28
18	20	Oxygen	0 : 48
18	5	Air	0 : 53
18	20	Oxygen	1 : 13
18	5	Air	1 : 18
18 - 9	30	Oxygen	1 : 48
9	5	Air	1 : 53
9	20	Oxygen	2 : 13
9	5	Air	2 : 18
9 - 0	30	Oxygen	2 : 48

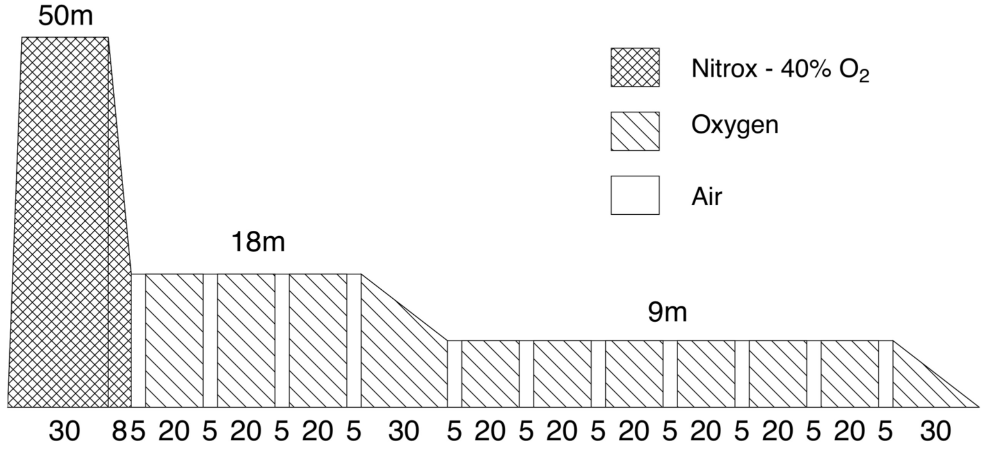
Table 6



Compression and decompression
Rate of compression at will. Decompression rate 0.3 m/min.
Patient
Breathing gas: Optional chamber gas or BIBS O_2 during compression. Time on O_2 running from arrival 18 m.
Chamber attendant
To breathe O_2 on BIBS identical to the patient from last O_2-period at 9 m. If extended with more than one O_2 period at 18 m **or** more than three O_2 periods at 9 m the attendant should breathe O_2 on BIBS identical to the patient from the second last O_2 period at 9 m. If repeated dive, the attendant breathes O_2 on BIBS identical to the patient from the third last O_2 period at 9 m.
Extensions
A maximum of two O_2 periods at 18 m and/or a maximum of six O_2-periods at 9 m.

Depth in metres	Time in minutes	Breathing gas	Running time h : min.
0 - 18	–	Air / O_2	–
18	20	Oxygen	0 : 20
18	5	Air	0 : 25
18	20	Oxygen	0 : 45
18	5	Air	0 : 50
18	20	Oxygen	1 : 10
18	5	Air	1 : 15
18 - 9	30	Oxygen	1 : 45
9	5	Air	1 : 50
9	20	Oxygen	2 : 10
9	5	Air	2 : 15
9	20	Oxygen	2 : 35
9	5	Air	2 : 40
9	20	Oxygen	3 : 00
9	5	Air	3 : 05
9	20	Oxygen	3 : 25
9	5	Air	3 : 30
9	20	Oxygen	3 : 50
9	5	Air	3 : 55
9	20	Oxygen	4 : 15
9	5	Air	4 : 20
9 - 0	30	Oxygen	4 : 50

Table 6A



Compression and decompression

This treatment table is to be used on the order of a physician only.

Compression to 50 m should be rapid. Time at 50 m includes time for compression.

Decompression rate from 50 to 18 m, is 4 m/min. From 18 to 9 and from 9 to 0 the rate is 0.3 m/min.

Patient

To breathe Nitrox with 40 % O_2 and O_2 on BIBS as shown.

Chamber attendant

To breathe Nitrox 40 at 50 m and during decompression to 18 m, 5 min air break after 20 min at 50 m.

To breathe BIBS O_2 identical to the patient from the third last O_2-period at 9 m.

If repeated dive and/or extensions to breathe BIBS O_2 identical to the patient from the fourth last O_2-period at 9 m.

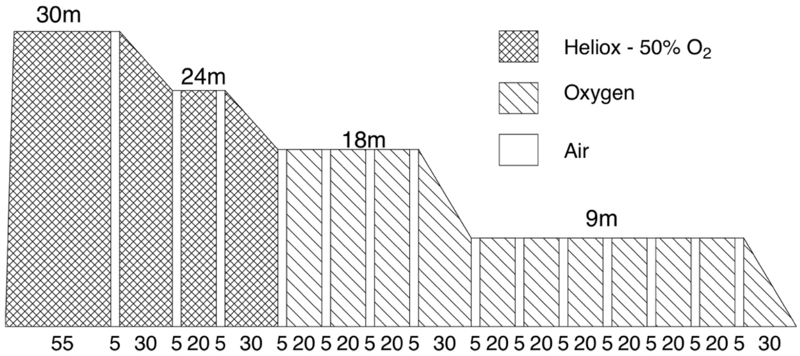
Extensions

A maximum of two O_2-periods at 18 m and/ or a maximum of six O_2-periods at 9 m.

* If the breathing gas at 50 m is air, the decompression rate is 1 m/min, and there is no 5 min air stop on arrival 18 m.

Depth in metres	Time in minutes	Breathing gas	Running time h : min.
0 - 50	-	Nitrox	-
50	30	Nitrox	0 : 30
50 - 18	8 *	Nitrox	0 : 38
18	5	Air	0 : 43
18	20	Oxygen	1 : 03
18	5	Air	1 : 08
18	20	Oxygen	1 : 28
18	5	Air	1 : 33
18	20	Oxygen	1 : 53
18	5	Air	1 : 58
18 - 9	30	Oxygen	2 : 28
9	5	Air	2 : 33
9	20	Oxygen	2 : 53
9	5	Air	2 : 58
9	20	Oxygen	3 : 18
9	5	Air	3 : 23
9	20	Oxygen	3 : 43
9	5	Air	3 : 48
9	20	Oxygen	4 : 08
9	5	Air	4 : 13
9	20	Oxygen	4 : 33
9	5	Air	4 : 38
9	20	Oxygen	4 : 58
9	5	Air	5 : 03
9 - 0	30	Oxygen	5 : 33

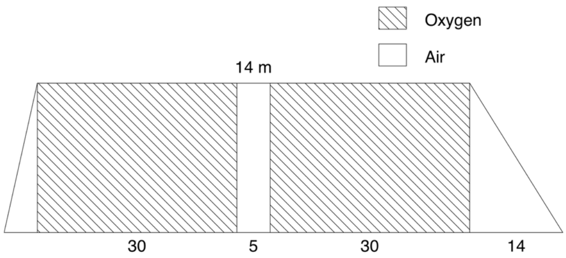
Table 6He



Compression and decompression This treatment table is to be used on the order of a physician only. Compression to 30 m at will. Time at 30 m includes time for compression. Decompression from 30 to 24 m and from 24 m to 18 m is 0.2 m/min, otherwise 0.3 m/min.
Patient Optional to breathe BIBS Heliox or chamber air during compression to 30 m.
Chamber attendant To breathe O_2 on BIBS identical to the patient from arrival 9 m. Identical procedure if repeated dive and/or table extensions.
Extensions A maximum of one O_2-period at 18 m and a maximum of three O_2-periods at 9 m.

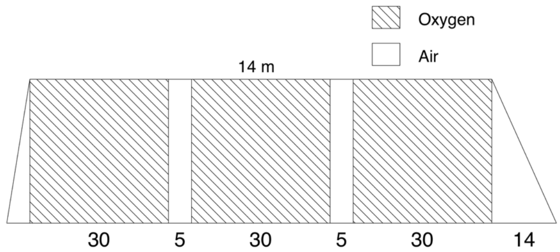
Depth (metres)	Time (min)	Breathing gas	Run. time h : min.
0 - 30	-	Heliox	-
30	55	Heliox	0 : 55
30	5	Air	1 : 00
30 - 24	30	Heliox	1 : 30
24	5	Air	1 : 35
24	20	Heliox	1 : 55
24	5	Air	2 : 00
24 -18	30	Heliox	2 : 30
18	5	Air	2 : 35
18	20	Oxygen	2 : 55
18	5	Air	3 : 00
18	20	Oxygen	3 : 20
18	5	Air	3 : 25
18	20	Oxygen	3 : 45
18	5	Air	3 : 50
18 - 9	30	Oxygen	4 : 20
9	5	Air	4 : 25
9	20	Oxygen	4 : 45
9	5	Air	4 : 50
9	20	Oxygen	5 : 10
9	5	Air	5 : 15
9	20	Oxygen	5 : 35
9	5	Air	5 : 40
9	20	Oxygen	6 : 00
9	5	Air	6 : 05
9	20	Oxygen	6 : 25
9	5	Air	6 : 30
9	20	Oxygen	6 : 50
9	5	Air	6 : 55
9 - 0	30	Oxygen	7 : 25

HBO-Table 14/60



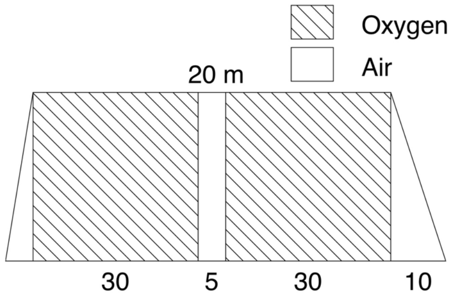
Compression and decompression
Compression rate at will.
Decompression rate 1 m/min.
If 14 m is not approached within 20 min, the first O_2 period is shortened accordingly. Maximum allowed bottom time 85 min.
Patient
Optional breathing O_2 on BIBS or chamber air during compression
Time on BIBS O_2 running from time of arrival at 14 m.
Chamber attendant
To breathe O_2 on BIBS during decompression.
Extensions
Not allowed.

HBO-Table 14/90



Compression and decompression
Compression rate at will.
Decompression rate 1 m/min.
If 14 m is not approached within 15 min, the first O_2 period is shortened accordingly. Maximum allowed bottom time 115 min.
Patient
Optional breathing O_2 on BIBS or chamber air during compression
Time on BIBS O_2 running from time of arrival at 14 m.
Chamber attendant
To breathe O_2 on BIBS during the last 15 min at 14 m and during decompression.
Extensions
Not allowed.

HBO-Table 20/60



Compression and decompression

Compression rate at will.

Decompression rate 2 m/min.

Patient

Optional breathing O_2 on BIBS or chamber air during compression

Time on BIBS O_2 running from time of arrival at 20 m.

Conscious patients should be given prophylactic medication to avoid oxygen induced seizures.

Sedated patients can breathe oxygen continuously (no air break required).

Chamber attendant

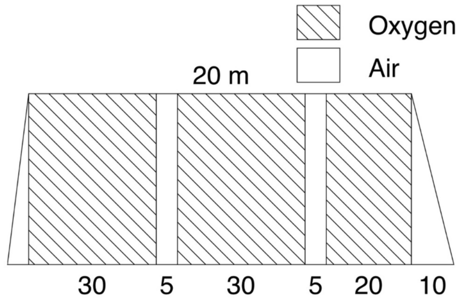
To breathe O_2 on BIBS during the last 10 min at 20 m and during decompression.

If repeated dive, the chamber attendant should breathe O_2 on BIBS during the last 20 min at 20 m and during decompression.

Extensions

Not allowed. Maximum allowed bottom time 70 min including compression.

HBO-table 20/90



Compression and decompression

Compression rate at will.

Decompression rate 2 m/min.

Patient

Optional breathing O_2 on BIBS or chamber air during compression.

Conscious patients should be given prophylactic medication to avoid oxygen induced seizures.

Sedated patients can breathe oxygen continuously (no air break required).

Chamber attendant

To breathe O_2 on BIBS during the last 20 min at 20 m, and during decompression.

If repeated dive the chamber attendant should breathe O_2 on BIBS during the last 30 min at 20 m and during decompression.

Extensions

Not allowed.

Maximum allowed bottom time is 90 min including compression

Phone list

Name	Phone no.

Notes

Procedures in the case of omitted decompression or uncontrolled ascent

EQUIPMENT	INCIDENT	ACTION
Recompression chamber	DCS symptoms	TT 6, Call 113, alert "diving accident"
	Uncontrolled ascent, no-decompression dive, ***SurD-O_2***	TT 5
	Uncontrolled ascent, no-decompression dive, ***Standard air table***	30 min O_2 breathing at surface
	Omitted staged in-water decompression <15 min, ***SurD-O_2***	TT 5
	Omitted staged in-water decompression <15 min, ***Standard air table***	Descend, extend decompression with one bottom time longer than required. Then breathe O_2 for 30 min at surface.
	Omitted in-water decompression >= 15 min	TT 5
Oxygen	DCS symptoms	Breathe O_2, call 113, alert "diving accident"
	Uncontrolled ascent, no-decompression dive	Descend, complete a safety stop then 30 min O2 breathing at surface
	Omitted staged in-water decompression stop(s)	Descend, extend decompression with one bottom time longer than required. Then breathe O_2 for 30 min at surface.
Nothing	DCS symptoms	Call 113. Alert "diving accident".
	Uncontrolled ascent after no-decompression dive or omitted in-water staged decompression stop(s)	Descend, extend decompression with one bottom time longer than required (alternatively complete a safety stop if this was a no-decompression dive). Contact diving physician.

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