

Changes – NDTT Rev 4

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The Norwegian Diving and Treatment Table (NDTT) is presently published in its third edition by an editorial team of AJ Arntzen, J Risberg and S Eidsvik. The publication is now due for revision and a new editorial team consisting of J Risberg, A Møllerløkken and O Eftedal has drafted the fourth edition. This draft version of the fourth edition has been distributed extensively within Norway for comments during 1st and 2nd quarter of 2016. The (new) editors have listed and discussed the changes in detail in a document in Norwegian language. The extent of the original Norwegian document (the change log) is too extensive to be translated in full, but the present document provides an overview of the most important changes – and the background for these.

Reservation

While this document tries to present the content of the NDTT, its history, development, the reason for revision and other content to the best of our ability, it remains an unofficial (non-binding) document from the editors' point of view. The original document (track changes document) as well as the NDTT is in Norwegian language. This document is not a literal translation of its Norwegian original, rather a condensation of the content. Finally: There may be discrepancies between the English and Norwegian draft versions of the NDTT due to non-synchronized updates. Updating the Norwegian version has highest priority and the update of the English version comes secondly. However, during the revision process the reader may identify the version of the tables by its page top text. As per July 18th 2016 the Norwegian as well as the English version awaits web-publication in Rev C4. A higher letter/number indicates a later revision. This document will not be regularly updated as minor revision is published – only if major changes are done.

A brief history and background for the NDTT

The NDTT was initially published by AJ Arntzen and S Eidsvik in 1980 as a NUI report. The tables were published as an independent publication in 1984. The third edition was published in 2004 (then with J Risberg as part of the editorial team) and a minor (and last) revision in 2008. In 2016 the responsibility for revising the tables were handed over to J Risberg. He chose A Møllerløkken and O Eftedal as his co-authors.

The NDTT contains air in-water decompression table based on the UK (Royal Navy) Table 11. The procedure for repetitive dives was the one of US Navy (USN) with repetitive group designators ranging A to Z. The RN Table 11 was at the time of first publishing of the NDTT considered a more conservative alternative to the USN air decompression schedules. The NDTT dissuaded against bottom times calling for in-water decompression exceeding 35 min and such profiles were indicated as exceptional dives (indexed by an asterisk in the tables). Nitrox diving was based on the conventional principle of equivalent air depth (EAD) and EAD tables were listed for Nitrox 32, 36 and 40. The procedures for Surface Decompression with Oxygen (SurD-O2) was based on the USN 1951 SurD-O2 tables, but were significantly modified based on North Sea diving experience. The NDTT SurD-O2 tables were made significantly more conservative for deeper depths with increased in-water decompression as well as longer chamber oxygen breathing time at 12 m. The ascent from 12m in chamber and back to surface pressure was modified relative to USN and made slower and with oxygen breathing throughout. In 2004 the SurD-O2 tables of the NDTT were made more conservative, limiting the longer bottom times for deeper dives. The procedures for diving at altitudes and flying after diving was based on the USN procedures though slightly modified. The

NDTT holds information on in-water air decompression, Nitrox diving, SurD-O2 diving, flying after diving, diving at altitude, the risk of oxygen toxicity, treatment of decompression illness, barotraumas as well as treatment of non-diving related disorders with hyperbaric oxygen. A number of therapeutic treatment tables are listed.

The need for table revision

The NDTT has been a de facto standard for Norwegian in-shore and off-shore diving since 1980. The formal track record of the tables is good suggesting an overall DCI risk of 0.06% in a total of 61 411 dives (1). The last case of DCI in offshore was reported 1999, and data from Haukeland University Hospital – serving the western part of Norway with emergency recompression treatment of DCI, suggest that the number of patients (including occupational divers) has declined the past 10-15 years. Overall the NDTT seems to serve the Norwegian diving community well and there is no suspicion of gross overrepresentation of DCI compared to other nations/table users. However, caution should be caught when assessing subgroups of dive profiles. The Kårstø dives –mainly completed with SurD-O2 technique, reported a threefold increase in DCI. Data from Shields and coworkers (6) suggest a three-to fourfold increase in DCI in SurD-O2 dives compared to in-water decompression, but the association between inert gas load (PrT) and DCI was the most predominant finding in the study. Segadal reported 2014 that the NDTT was less conservative than their US, Canadian and German/French counterparts (3). The most striking difference was the difference in decompression obligation (presented as “Total Decompression Time” comparing USN Diving Manual Rev 6 to NDTT Rev 3. Gerth and Doolette has published a report comparing the previous version of USN Diving manual (Rev 5, USN56 decompression model) to its present version (Rev 6, VVal18 model) with respect to DCI estimate using the probabilistic model of the USN (5). The report details that the longest bottom times of the in-water air decompression dives as well as a substantial number of SurD-O2 dives have DCI estimates in the range of 7-10%. Interestingly, the NDTT 3rd edition has TDT very close to that listed in USN Diving Manual Rev 5. Discrete tests of some of the NDTT 3rd ed SurD-O2 tables suggest DCI risk ranging 7-9% (W Gerth, personal communication 2016). Informal and unsubstantiated rumours have since long suggested that the SurD-O2 tables may be unsafe in the 20-30 m range. However, no firm data has to yet supported this assumption. We consider that there now exists a bulk of indications suggesting that the longest and shallowest air decompression schedules of the NDTT Ed 3 is too liberal. Further, a number of the exceptional air decompression profiles (indicated by asterisk) as well as the Norwegian SurD-O2 profiles in general (but 20-30 m range in particular) would have an excessive risk of DCI and needed to be revised.

Procedure for table revision

It was our opinion that the Norwegian air decompression, in general, had demonstrated acceptable safety record and there would be no reason to make a shift to an alternative table set. However we would like to preclude those profiles associated with an excessive risk of DCI. Based on the fact that most of the non-exceptional air in-water decompression dives of NDTT Ed 3 had a DCI risk less than 5%, this was targeted as the upper acceptable risk for air decompression as well as SurD-O2 decompression dives in the 4th edition of the NDTT. To allow for a situation in which emergencies would call for longer bottom times, the exceptional dives (indicated by asterisk) would be allowed to reach 6%. The air decompression tables were revised on the basis of data extracted from the work of Gerth and Doolette (5). NDTT Ed 3 air decompression profiles with TDT equal or longer to their USN56 counterpart with a $P_{DCI} < 5\%$ would be accepted in the new edition. Profiles with P_{DCI} of 5-6 % would be accepted for exceptional dives. The end result of this was that the majority of non-exceptional air decompression profiles listed in the 3rd ed of NDTT was copied without change to the

new table edition. An exception was made for the 15m table for which a significant reduction in allowed bottom time was imposed. A number of the longest bottom times, listed as exceptional dives in the 3rd edition of the NDTT has been withdrawn as their P_{DCI} exceeds 6%. The most significant changes regarding the air decompression tables has thus been imposed on exceptional dives. From a practical point of view this has limited relevance since such dives should not be planned for.

The changes in Repetitive Group Letter Designator (RGD), the reduction of these during surface interval and penalty to bottom time depending on the RGD has been modified in agreement with USN Diving Manual Rev 6. The same holds true for minor modifications related to altitude diving (RGD letter designation) and flying after diving restrictions. These changes are comparatively small.

The major challenge was how to improve safety for the SurD-O2 tables printed in the 3rd edition of the NDTT. These tables were modified from their original source (USN51) to an extent not allowing easy assessment of DCI risk. We have taken the decision to rely on the USN Diving Manual Rev 6 procedure for SurD-O2 diving. The one exception we have made is to use the VVAL79 parameter-set as listed in a later report of Gerth and Doolette (7). The effect on the SurD-O2 tables is minimal, but the changes are justified with a thorough review in the cited report (7). The change to the new USN SurD-O2 procedure will have significant consequences when compared to NDTT 3rd ed procedures. Most importantly the in-chamber oxygen breathing time will be substantially prolonged (for many of the longest dives in the order of 40-50 min).

The most important practical/operational consequences of the changes suggested

The main operational consequences of the changes introduced to NDTT Ed 4 compared to Ed 3 are these:

- Standard air decompression table
 - Initial ascent time to deepest deco stop not to be included in stop time
 - 12 and 15 m table: The possibility for the very long exceptional dives have been removed
 - A single dive is defined as a dive lwith a surface interval exceeding 16 (previously 12h)
 - Small adjustments in RGD for each profile, the penalty for each RGD and surface interval RGD reduction.
 - Moderate adjustments in flying after diving recommendations (relative to RGD) and RGD attribution for diving at altitude
 - (Minimal changes in limit for no-decompression dives and decompression obligation for non-exceptional dives)
- SurD-O2 tables
 - USN (USN Diving Manual Rev 6) procedures implemented with major changes for decompression procedures including
 - In-water ascent rate 10 m/min
 - Most shallow deco-stop at 12 m
 - Initial recompression to 15m for 15 min (the succeeding decompression to take place at 12 m)
 - Typically 30-50 min longer in-chamber O2 breathing time, but shortened in-water decompression obligation
- Air and SurD-O2 tables

- Air should not be planned to be used as a breathing gas deeper than 50m.
- UK (HSE) bottom time limitations clearly identified in the tables to facilitate compliance with petroleum related diving.
- The table present a practical approach to metric the considerations to be taken when individual and environmental factors (“J-factors”) unfavourably affect the decompression obligation.
- Diving in relation to exploration of oil and gas
 - This is a totally new chapter detailing relevant matters of petroleum related diving inshore and offshore.
- Multilevel diving
 - A procedure for the use of these tables for multilevel diving has been presented
- Nitrox diving
 - pO₂ max not to exceed 1.5 Bar
- Emergency procedures
 - Omitted decompression (in-water) during SurD-O₂ diving to be treated with TT5 without consideration of extent of omitted decompression time
- Diagnostic and emergency action plan
 - Chapters restructured, but no operational consequences
- Treatment tables
 - Minor changes in TT 6He, TT 14/90 and TT 14/60

References

(Only a few of the below listed references are cited in the text above, they were however referred to in the original Norwegian “track changes” documents.)

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Contact information and update

Please feel free to contact the editorial team through Jan Risberg: post@dykketabeller.no

Updated status on the publication is available at www.dykketabeller.no

Detailed list of changes – presented per chapter

This document summarizes major changes in Rev 4 (2016) of NDTT compared to Rev 3 (2008). The document does NOT identify minor changes in text, corrections of typos or graphical corrections.

Introduction

Summarizes major changes.

Standard Air Decompression Table

Ascent time from bottom to first decompression stop is not included in stop time on first staged stop. Ascent rate from bottom to first stop to go 10 m/min. Delay for 1 min allowed without added decompression penalty.

A single dive. Dive separated at least 16 hours after the preceding

Repetitive dive. A dive separated shorter than 16 hours after the preceding. However it is underscored that not all repetitive dives will be penalized with an addition to the actual bottom time.

Criterion for indexing dives as exceptional dives (*tagging): P_{DCS} 5-6%, staged in-water decompression time >35 min or diving depths >50 msw breathing air.

Standard Air Decompression Tables matrices (Chartered tables ranging 6 – 60 msw)

A bold horizontal threshold line indicating bottom time limitations per Norsok U-103/Norsok U-100 and HSE has been added to all profiles. The boundary line is not regulating inshore diving for non-petroleum related diving.

The table for reduction of repetitive group designator (RGD) during surface interval has been changed in agreement with USN Diving Manual Rev 6 recommendations, and the intervals have been adjusted to assure that any specific surface interval will fall within one RGD (previously the borderline time would be listed in two boxes).

Minimal changes for non-exceptional dives.

Total decompression time (TDT) for exceptional dives have been harmonized with USN Diving Manual Rev 6 (USN6). This has been done by selecting a decompression schedule from Rev 3 of NDTT with a TDT matching the requirement from USN6.

To illustrate this – consider the example below from the 33 msw table:

Rev 3: The No-Decompression Limit was 15 min. Maximum allowed bottom time for a non-exceptional dive 45. Rev 4: Identical limits.

Rev 3: Maximum tabulated bottom time for exceptional dive: 80 min. Rev 4: Shortened to 55 min.

Rev 3: TDT 50 min for a 55 min (exceptional) bottom time. Rev 4: TDT 70 min for the very same dive.

Changes in allowed maximum bottom time for no-decompression dives:

12msw: Increased by 15 min to 150 min

15msw: Reduced by 20 min to 65 min

21msw: Increased by 5 min to 45 min

24msw: Increased by 5 min to 35 min

Repetitive Group Designators are adjusted in agreement with USN6

Repetitive Group Designator reduction chart (i.e. the reduction in residual Nitrogen time during surface interval): Adjusted in agreement with USN6

A procedure for multilevel diving using the tables is described and the limitations that should be adhered to.

Diving at Altitudes above 250 m

Repetitive Group Designators will be adjusted (Residual Nitrogen Time reduced) during transfer to altitude similar to a surface interval at sea level.

For dives at altitudes exceeding 1500 masl the Repetitive Group Designator has been increased.

Flying after diving

Minimum time before flying after SurD -O2 fixed to 21 h. No evidence to support Rev 3 recommendations

Required surface interval for flying after diving adjusted in agreement with USN6 for the various Repetitive Group Designators

A section describing transfer to moderate heights after diving (e.g. mountains) has been included.

Decompression procedures for rescue divers in need to dive in mountain waters after a sea dive has been added.

Multilevel diving

This is a completely new chapter describing the use (and limitations) of the tables for multilevel diving.

Dive computers

The chapter has been rewritten, but no factual changes related to occupational diving. Use of dive computers in occupational diving is not recommended.

Oxygen Toxicity

The example has been changed in agreement with the changes in (new) SurD-O2 procedures

Diving in the Norwegian Oil and Gas Industry

This chapter is new.

Nitrox Diving

Maximum recommended pO₂ has been reduced to 1,5 Bar as suggested by international and oil & gas related standardization.

Surface Decompression Using Oxygen

The SurD-O2 procedures are based on USN6.

The previous description of recommended use of diving equipment for combined Nitrox and SurD-O2 has been removed.

Time for initial ascent from bottom to first stop should not be included in stop time at the first in-water staged decompression stop.

Most shallow staged stop is 12 msw (Rev 3: 9msw)

Criterion for indexing schedules as exceptional dives (*): P_{DCS} 5-6% or OTU>300

Initial chamber decompression to take place at 15 msw for 15 min, succeeding decompression at 12 msw.

Oxygen breathing periods increased from 20 to 30 min.

5 min air break prescribed before chamber decompression if the diver has been breathing oxygen for 30 min.

Chamber decompression to take place with 10 m/min ascent rate with the diver breathing chamber gas.

An error related to decompression time if escaping a SurD-O2 procedure by means of Table 1 has been corrected.

EAD-tables

pO₂ provided by two decimals (one of these were provided with three decimals in Rev 3).

Graphical distinction for diving depths exceeding recommended maximum pO₂ by 1.5 Bar (italics and delimitation line)

SurD-O2 tables (individual chartered schedules)

Completely revised in agreement with USN6, though minor adjustments are made due to the implementation of VVal79 parameter set (rather than VVal18M as per USN Diving Manual Rev 6).

A bold horizontal delimitation line has been inserted to show Norsok U-100/U-103 and UK HSE bottom time restrictions. These limitations are not applicable for non-petroleum related diving in Norway.

Prevention of Decompression Illness

Matrices have been included to facilitate assessment of risk factors for DCI and mitigating actions if multiple risk factors are present. Assessment relevant for Standard Air Dives as well as SurD-O2 dives.

A safety stop is recommended, though not mandatory, for *all* dives.

Deep Chamber Dives

Moderate adjustments of decompression procedures. These are based on USN Diving Manual Rev 6 procedures for decompression using in-water oxygen breathing. Further restrictions on flying after a deep chamber dive.

Emergency Procedures

SurD-O2 dives with omitted decompression: Treat with TT5. USN6 procedure considered too complex for occupational diving. Flowcharts adjusted to present the decision chain more intuitively.

Decompression Illness

Reference to the effect of treatment delay for outcome has been removed. No evidence to support this statement, rather intensity of symptoms seem to be the major predictor for long term outcome.

Barotrauma

No change

Treatment of Decompression Sickness and Air Embolism

Haukeland University Hospital duty diving physician (through Emergency Dispatch Service): Phone number corrected. Midazolam added as treatment option for oxygen induced seizures in addition to diazepam. Nasal administration added in addition to suppositories and enema.

Oxygen Treatment of Non-Diving Related Disorders

Details regarding Norwegian national responsibilities for HBO-treatment adjusted. Concentration of "Klorin" used as an disinfectant corrected and specified. Minor changes in text related to gas gangrene and CO intoxication.

Emergency measures – diving accidents

New chapter with consolidated flowchart. A chart for CPR is included.

Diagnostics

The checklist has been extracted and presented as such (a checklist) in a separate section. The chapter has been shortened and matters related to serious accidents removed to the preceding chapter.

Examination list

The examination items have been serialized and formatted in a checklist-layout. Slight modifications of text in the checklist.

Treatment Tables

Table 6He adjusted (closer compliance with original version (Cx30) and in agreement with NOR/SWE military harmonization)

Table 14/60 and 14/90 adjusted removing 3 msw stop.