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## DCI INCIDENCE FOR SurD NDC TABLES IN THE RANGE OF 48 TO 51 METRES

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### INTRODUCTION

The Netherlands Diving Centre (NDC) decompression tables, also known as DADCODAT (DCD) tables, were designed in 1988 using the same neo-Haldanian computational model that generated the Eastern Scheldt tables(3). The tables aimed at a decompression illness (DCI) incidence not higher than 0.5%. To control this, users were obliged to report all dive data to NDC, but this was stopped in 1994. The main reason was that diving companies and NDC considered the number of data sufficient to prove the reliability of the tables. Therefore, they were not willing to put more effort in further dive data collection. However, in recent years there was some concern that DCI incidence exceeded the accepted limit for surface decompression (SurD) after air diving in the depth range between 45 and 50 msw, particularly during the NDC diving courses. This caused us to look further into the matter.

### METHODS

Fortunately, the diving school kept book of all dives between 1988 and 1998. Also all reports on cases of DCI were made available. An open sequential design (1) was used to test the acceptability of DCI incidence. It consists of a plot of the number of cases of DCI against the number of dives, sequenced in time. The area of rejection or acceptance is then marked by respectively an upper and lower straight line, depending on the selection criteria. We selected a bends incidence  $p_0$  of 0.5% that is not to be rejected more than  $\alpha=0.025$  proportion of the time, and an incidence  $p_1$  of 5.0% that is not to be accepted more than  $\beta=0.025$  proportion of the time. This leads to our sequential selection rule as depicted in Figure 1.

Since DCI incidence seemed somewhat higher in recent years, we did field tests during the deep diving training in the last two weeks of two courses in 1997. Dive profiles were monitored with Citizen Hyper Aqualand watches (Tokyo, Japan) and pre-cordial Doppler monitoring (2.5 MHz, continuous/pulsed Doppler monitor DBM9610, Techno Scientific, Inc., Toronto, Canada) was done at 20, 60, and 100 minutes after decompression, at rest and after a deep knee bend. Bubbles were graded according to the Kisman-Ma-

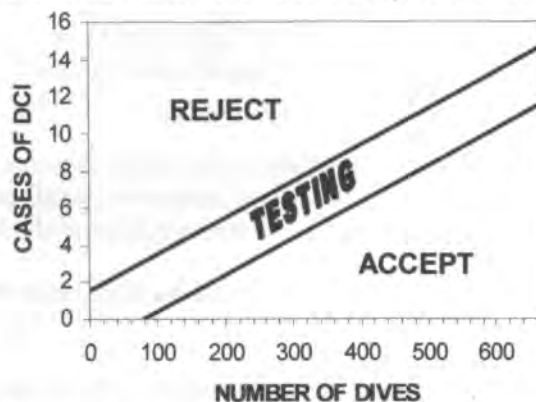


Figure 1. Open sequential selection rule. Accept for DCI incidence < 0.5%

$$p_0 = 0.005 \quad p_1 = 0.05$$

surel (KM) code (2).

## RESULTS

A total of 1091 SurD dives were made during professional diving training to depths between 45 and 50 msw in the period from 1988 until 1998. These included the 70 dives of the field tests. There were 661 dives on the 48 msw table, 412 dives on the 51 msw schedule, and back up procedures because of decompression irregularities in 18 dives. The latter were excluded from further analysis. In total 10 cases of DCI were reported, 8 on the 48 msw table and 2 on the 51 msw table, all of them joint pain or skin bends without any neurological symptoms. Information on dive time and depth of the remaining 1073 dives is presented in Table 1.

		NUMBER OF DIVES	DIVE TIME AVG (SD)	DIVE DEPTH AVG (SD)	CASES OF DCI
<b>51 MSW</b>	TOTAL	412	27.3 (1.6)	47.4 (0.9)	2
	WITHOUT J-FACT	251	27.0 (1.8)	48.0 (0.2)	2
	TABLE TIME 30 MIN	248	27.1 (1.5)	48.0 (0.2)	2
<b>48 MSW</b>	TOTAL	661	27.8 (1.1)	45.9 (0.7)	8
	WITHOUT J-FACT	652	27.8 (1.1)	46.0 (0.6)	8
	TABLE TIME 30 MIN	648	27.8 (1.0)	46.0 (0.6)	8
	FIELD TESTS	70	27.4 (1.8)	45.4 (0.6)	1

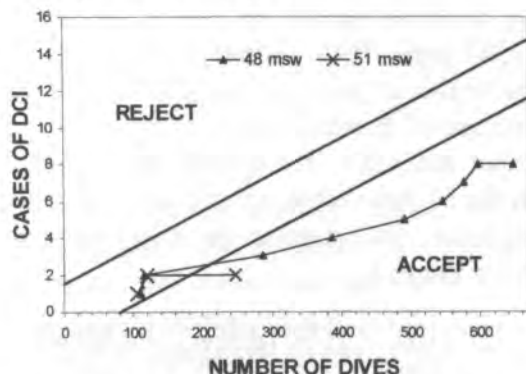
**Table 1.** Analysis of 1073 SurD dives with respect to diving time and depth. AVG=average, SD= standard deviation.

It appeared that on the 51 msw table "Jesus factors" were applied in quite a number of dives; in 161 dives the next deeper depth or the next longer time was taken for table selection. For the 48 msw table, this was rarely done. In most dives, the 30 minutes schedule was used. If we exclude "J-factoring" and the other table times, 248 dives

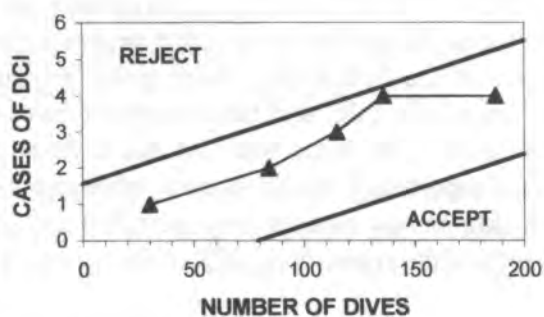
	In water stops (metres)					Stops in deco chamber						Tot. deco time (min)
	21	18	15	12	9	12 oxy	9 air	9 oxy	6 air	6 oxy	3 oxy	
<b>48 msw</b>		2	3	4	4	10	-	10	5	10	10	64.0
<b>51 msw</b>	1	2	3	6	4	20	5	10	-	10	10	77.3

**Table 2.** NDC SurD decompression for table time of 30 minutes to 48 or 51 msw.

on the 51 msw/30 min. table and 648 dives on the 48 msw/30 min. table remain, still including all 10 reported cases of DCI. The SurD decompression schedules at stake are depicted in Table 2.



**Figure 2.** Sequential selection rule applied to 648 dives on 48 msw / 30 min and 248 on 51 msw / 30 min. schedule.



**Figure 3.** Sequential selection rule applied to 48msw/30min. dives starting in December 1995.

Applying these data to our open sequential selection rule, as shown in Figure 2, demonstrates that DCI incidence for both schedules is well within the accepted range. If data collection had started in December 1995, however, the 48msw schedule would have been on the border of rejection (Figure 3). This could be a coincidence or a change in variables involved. The only change made in the training was that course duration was shortened from 12 to 10 weeks in 1995. Doing the same course within a shorter time could have made diving more stressful.

DATE	DIVER	DIVE TIME (MIN.)	DIVE DEPT H (MSW)	BUBBLE GRADE (BG) AFTER DECO			BG MAX.
				20'	60'	100'	
				R / E	R / E	R / E	R / E
1/4	A	26	45	0 / 0	0 / 0	0 / 2	0 / 2
2/4	A	29	45	0 / 0	1 / 2	0 / 0	1 / 2
3/4	B	27	45	1 / 2	Skin bends		1 / 2
4/4	C	28	46	0 / 0	1 / 2	0 / 0	1 / 2
7/4	D	28	45	1 / 3	0 / 0	0 / 0	1 / 3
7/4	E	28	45	3- / 3	0 / 2	0 / 0	3- / 3
30/9	F	28	45	0 / 0	1 / 2	0 / 1	1 / 2
1/10	G	28	46	0 / 2	0 / 2	0 / 2-	0 / 2
1/10	H	28	46	0 / 2-	0 / 0	0 / 0	0 / 2-
2/10	G	28	46	0 / 2-	0 / 2	0 / 2	0 / 2

**Table 3.** Field tests: bubble scores 20, 60 and 100 minutes after decompression, at rest (R) and after a deep knee bend (E), with listing of maximum bubble grade.

In the field tests were 70 dives on the 48msw/30min schedule, with one case of skin bends. Bubbles were detected in 10 cases, but only two with bubble grade > 2, as shown in Table 3. For two divers (A and G), bubbles were found after two dives

The recorded dive profiles were pretty much square wave, as the example in Figure 4 shows. Therefore, these dives during the courses can be taken as realistic for testing the tables at stake. However, the decompression profile is not always accurate, as shown in Figure 4, since the trainees have to operate the chamber in turn and are of course not very experienced. This could also be a promoting factor as far as the occurrence of DCI is concerned.

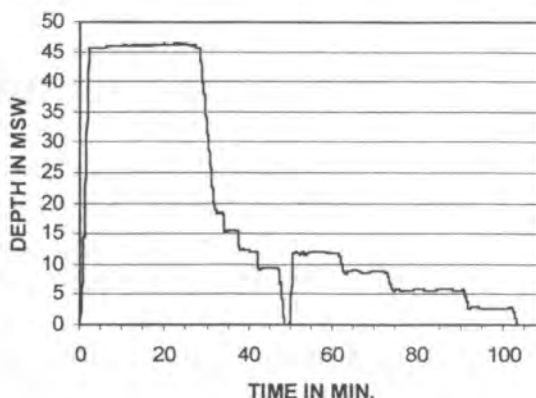


Figure 4. Example of dive and decompression profile, recorded during field tests

## CONCLUSIONS

The performance of the NDC SurD tables in this specific range is well within the accepted limits. There may be some concern about the DCI incidence within the last two years. Shortening the diving course from 12 into 10 weeks, making it more stressful, could be a factor that contributes to a higher DCI incidence. However, this is not supported by the results of the field tests so far. As many variables may be involved, continuous collection of dive data remains important to guard the reliability of decompression tables for future operations.

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