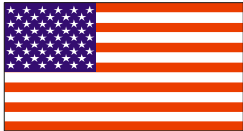


# Water Temperatures for Matched Cold Exposures in Divers With or Without Wet Suits During Air Decompression Dives



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## INTRODUCTION

Diver thermal status is an important determinant of DCS risk.(1,2) A large fraction of modern military decompression data that underlies decompression tables and models was obtained using divers wearing wet suits in cold water. For instance, about 80% of the man-dives in the calibration data for the USN93 and BVM(3) probabilistic models were conducted by wet suited divers immersed in water at a mean temperature of 63 °F. A decompression trial in which divers were to wear only shorts and t-shirts (3) required identification of a water temperature to approximate diver thermal exposures in these earlier trials.

## METHODS

The general procedure was to replicate the thermal conditions of a typical dive from the existing calibration data set in a test dive conducted in cold water at depth with divers wearing wet suits. Diver subjective thermal status and mean skin temperature were recorded and used to guide water temperature selection for a 210-minute experimental dive in which divers wore cotton shorts and t-shirts.

Twelve divers wearing 5–7 mm neoprene full wet suits, breathing surface-supplied air via full face masks, and immersed in 60 °F (16 °C) water in the NEDU Ocean Simulation Facility wet pot were compressed at 60 fsw/min (18 msw/min) to 100 fsw (30 msw) for 30 minutes bottom time. Upon reaching bottom, divers performed intermittent (6 minutes work/6 minutes rest) 125 watt cycle ergometer work until one minute before decompression, then rested during 99 minutes of ensuing decompression (see Figure 1).

Skin temperatures at chest ( $T_{sk,chest}$ ), back ( $T_{sk,back}$ ), forearm ( $T_{sk,forearm}$ ), and calf ( $T_{sk,calf}$ ) were recorded continuously. Temperatures at the four sites were approximately equally weighted (Eq. 1) for calculation of mean skin temperature ( $T_{sk,mean}$ ). (4) Subjective thermal status scores were elicited every 15 minutes (see Table 1).

$$T_{sk,mean} = \frac{(T_{sk,chest} \times 0.29425) + (T_{sk,back} \times 0.22425) + (T_{sk,forearm} \times 0.22425) + (T_{sk,calf} \times 0.25625)}{4} \quad (1)$$

Two days later, eleven of the same divers wearing shorts and t-shirts completed a dive simulating the thermal conditions of an experimental 170 fsw/30 minute air dive with 180 minutes of decompression. While immersed to 3 fsw (mid-chest depth) in 85 °F (29 °C) water, the divers rested for 3 minutes, performed 115 watt cycle ergometer work for 26 minutes, then rested for 181 minutes. Thermal status scores were elicited every 15 minutes. Skin temperature was not measured because unclothed skin temperature rapidly approaches within 1 °C of water of this temperature.(5)

Table 1. Numeric Scale for Subject Thermal Status Self-Assessment

Score	Thermal Discomfort	Score	Thermal Discomfort
0	None at all	5	Severe, Occasional Shivering
0.5	Very, very slight	6	
1	Very slight	7	Very severe, Involuntary Shivering
2	Slight	8	
3	Moderate	9	Very, very severe
4	Somewhat severe	10	Maximally severe, Unbearably cold

## RESULTS

Typical data for wet suited divers during the 100 fsw/30 minute air decompression dives are shown in Figure 1. Mean skin temperature stabilized between 80 and 85 °F after ergometer work, while thermal status scores, shown for all divers in the top panel of Figure 2, rose from an initial median of 1 and stabilized at 5 (occasional shivering).

In divers wearing shorts and t-shirts in 85 °F water, thermal status scores, shown for all divers in the bottom panel of Figure 2, also rose from an initial median of 1 and stabilized at 5. During the final 75 minutes of immersion, thermal status scores were not significantly different between the different dive conditions (paired Wilcoxon signed rank test,  $p > 0.05$ ).

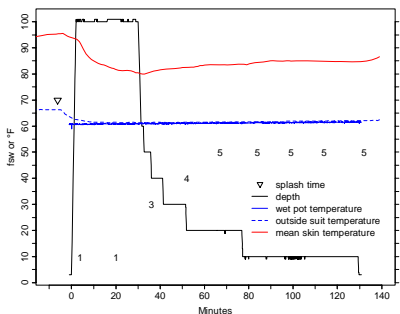


Figure 1. Typical depth-temperature-time record from a wet suited diver immersed in 60 °F water during a 100 fsw/30 minute air decompression dive (Blue Diver, Team 2). Plotted numerals are the thermal status scores.

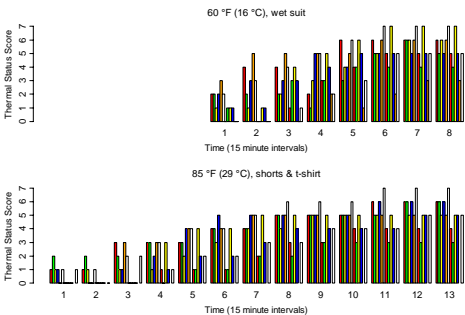


Figure 2. Diver self-reported thermal status scores at 15-minute intervals while wet suited and immersed in 60 °F water during a 100 fsw/30 minute air decompression dive (top panel), and while wearing only shorts and t-shirts in 85 °F water (bottom panel). The two dives were of different durations and are aligned at reach surface time. Thermal status scores in the last five intervals do not differ significantly between the two dives.

## DISCUSSION

The present wet suit dive was chosen to typify the cold stress of decompression dives in the calibration data for probabilistic models. Diver thermal status is rarely quantified in this calibration data. The degree of cold stress in divers depends on water temperature, duration of immersion, and insulation. The dive was conducted to 100 fsw for near maximal decrease in wet suit insulation due to compression.(6) The bottom time and decompression schedule were selected from “EDU885”, an earlier NEDU decompression trial (7) that contributes a substantial portion of the probabilistic model calibration data. The water temperature was representative of dives of this duration in the calibration data. Divers surfaced from the present wet suited dive in the same “visibly chilled and shivering” condition as reported for divers surfacing from EDU885 dives. Divers wearing only shorts and t-shirts during the longer dive in 85 °F water also appeared chilled and shivering upon surfacing.

## CONCLUSIONS

During prolonged decompression dives, cold stress for divers without wet suits in 85 °F water is similar to that for divers wearing wet suits in 60 °F water.

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