THERMAL ASSESSMENT OF DIVING GARMENTS USING AEROGEL SUPER-INSULATION FABRICS

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INTRODUCTION

An area of primary interest in diving safety and effectiveness is improving the ability of free-swimming and tethered divers to operate in thermal extremes through improved suit materials. The objective of this study, sponsored by the Office of Naval Research, was to compare the thermal protection afforded to divers using garments constructed from recently developed aerogel super-insulation materials with that of commercially-available garments using Thinsulate.

METHODS

Six U.S. Navy male divers conducted long-duration cold water dives (up to 3 hour durations) in a 5 meter deep test pool with water temperature maintained between 1.7 and 4.4 ºC (35 and 40 ºF). During successive dives, separated by a minimum of 40 hours, divers alternately wore drysuits with liners constructed from either an experimental aerogel super-insulation or a commercial 400-weight Thinsulate fabric. Core, finger, toe, and mean skin temperatures were recorded as the divers remained immobile on the bottom of the test pool, and diver comments concerning thermal comfort were recorded at 30-minute intervals.

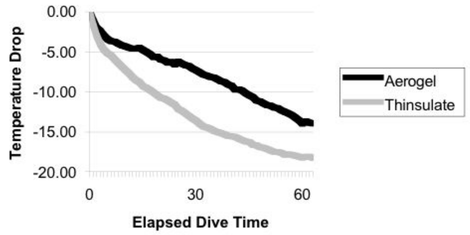

Figure 1. Mean finger temperature (°C) drop from baseline as a function of thermal garment performance. Data are shown up to the shortest dive (63 min) recorded.

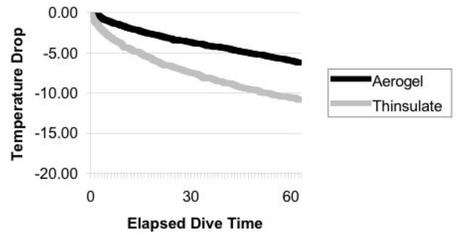

Figure 2. Mean toe temperature (°C) drop from baseline as a function of thermal garment performance. Data are shown up to the shortest (63 min) recorded dive.

Figure 3. Mean skin temperature (°C) drop from baseline as a function of thermal garment performance. Data is shown up to the shortest (63 min) recorded dive.

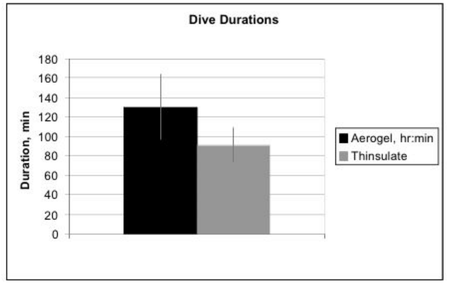

Figure 4. Mean dive duration (min) as a function of thermal garment. Error bars represent one standard deviation.

RESULTS

The experimental aerogel garment resulted in increased dive durations for all dive subjects, on average 43% greater than dives with the commercial Thinsulate liners. Finger, toe, and mean skin temperatures likewise showed improvements (on average 4ºC higher finger temperatures one hour into the dives, 5ºC higher toe temperatures, and 3ºC higher mean skin temperatures based on a four point weighted average). Diver surveys, during and after the testing, confirmed the overall thermal subjective comfort benefits of the experimental liner constructed from the aerogel super-insulation fabric.

CONCLUSIONS

This investigation has demonstrated that significant improvements in diver thermal protection can be achieved by incorporating aerogel super-insulation fabrics into drysuits. The thermal properties of these materials have also been shown to be minimally impacted by water immersion or compression.

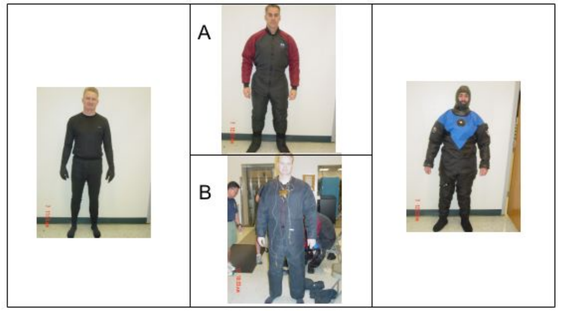

Figure 5. Layers of diver-dress from left to right: Capilene lightweight underwear, socks, and gloves; (A) M400 Thinsulate thermal undergarment, or (B) the prototype aerogel liner (booties, gloves, and skullcap not shown); and TLS350 dry suit with an attached hood (three-finger dry gloves not shown). A DTTR worn around the neck is shown in (B).

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