

THERMAL ASSESSMENT OF DIVING GARMENTS USING AEROGEL SUPER-INSULATION FABRICS

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40th Annual UHMS Scientific Meeting
Maui, Hawaii
13-17 June 2007

Office of
Naval Research

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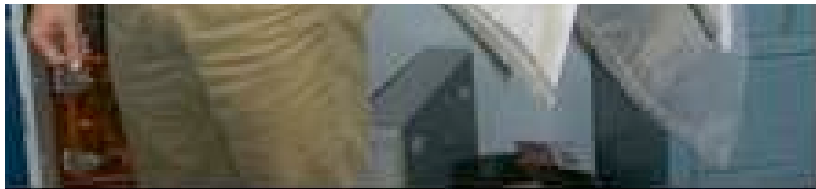
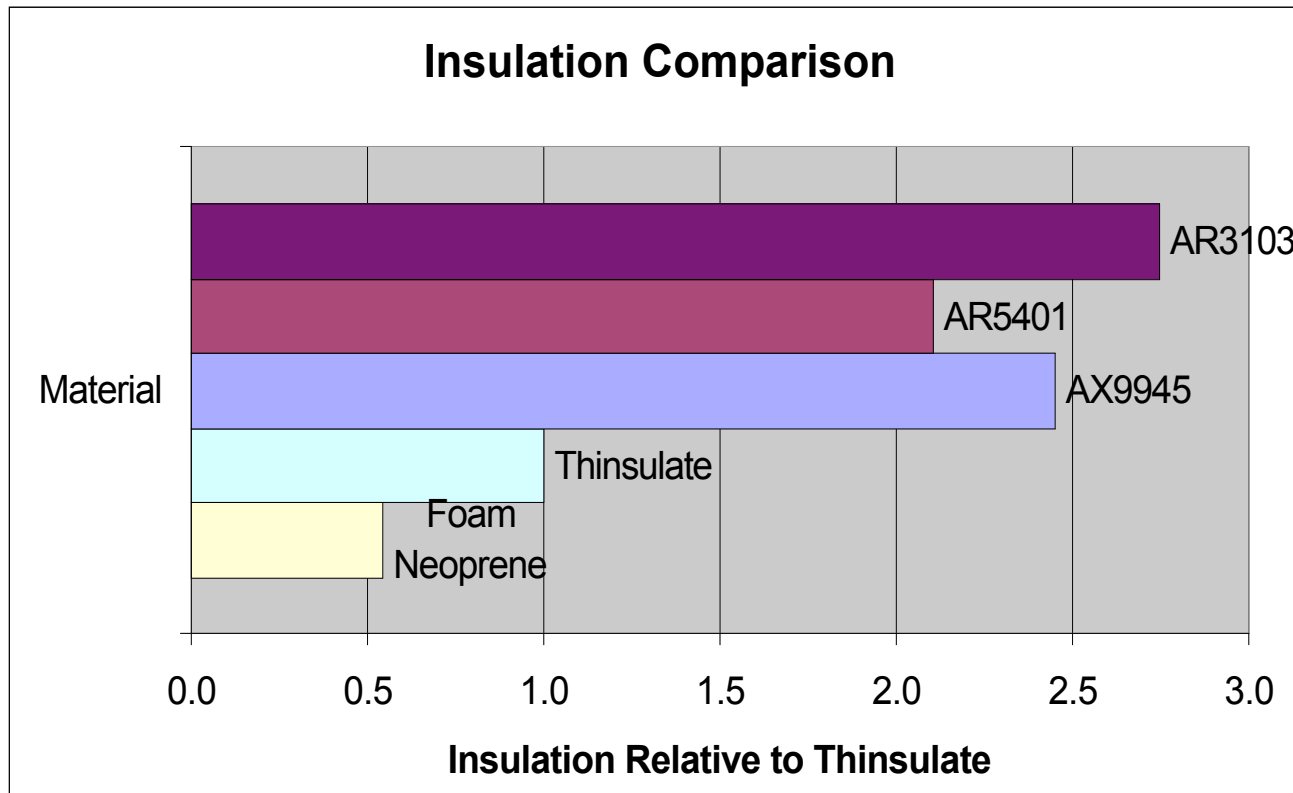
SUPER-INSULATING AEROGELS

- Originally developed in early 1930s (Kisler)
- Ultra low thermal conductivities (approaching that of a vacuum)
- Low density, highly porous materials formed by extracting the liquid from a micro structured silica gel. Open celled structure with an average pore size approximately 10 nm.

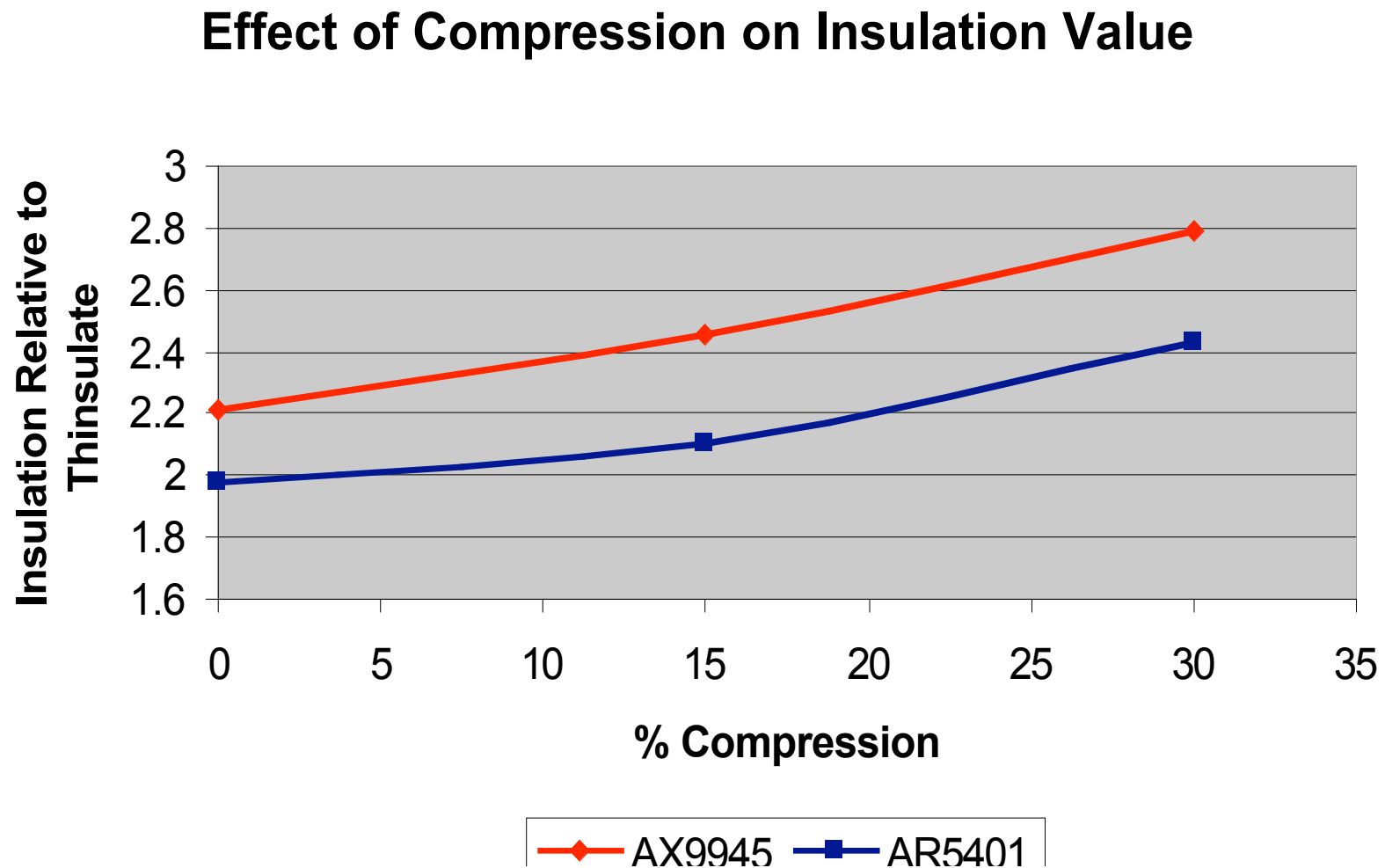


Clear monolithic sheets
“Frozen smoke”

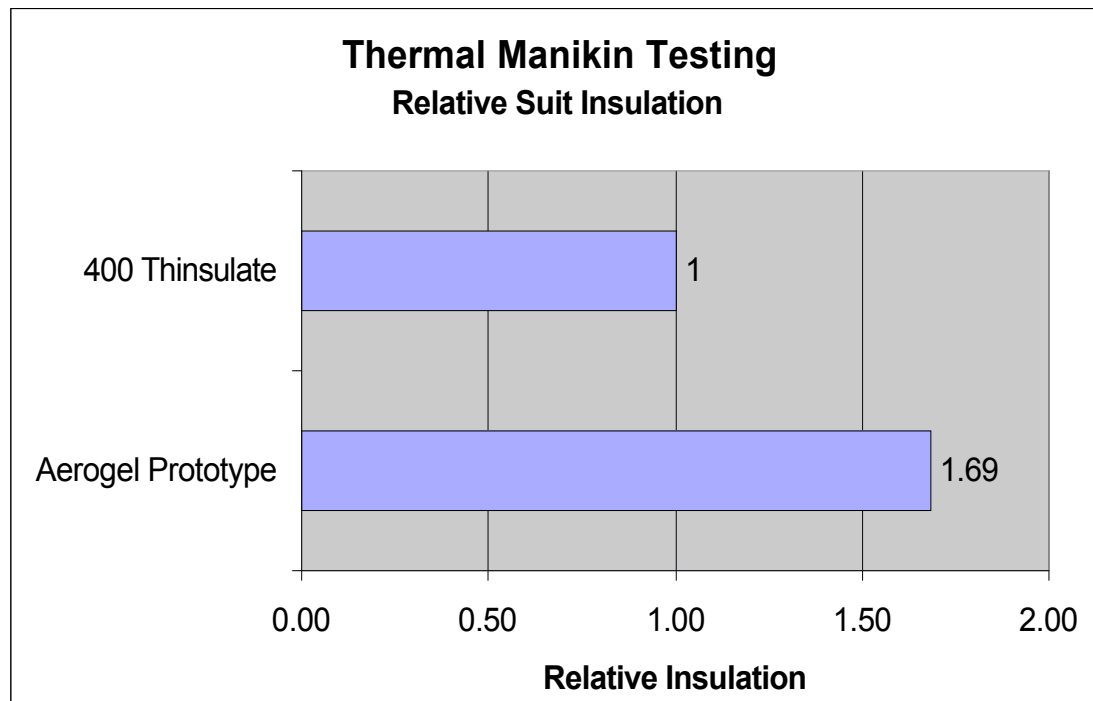
FLEXIBLE AEROGEL BLANKETS



INSULATION IMPROVES WITH COMPRESSION



THERMAL MANIKIN TESTING



HUMAN TRIALS AT NEDU



Capilene LW Underwear



Aerogel Prototype



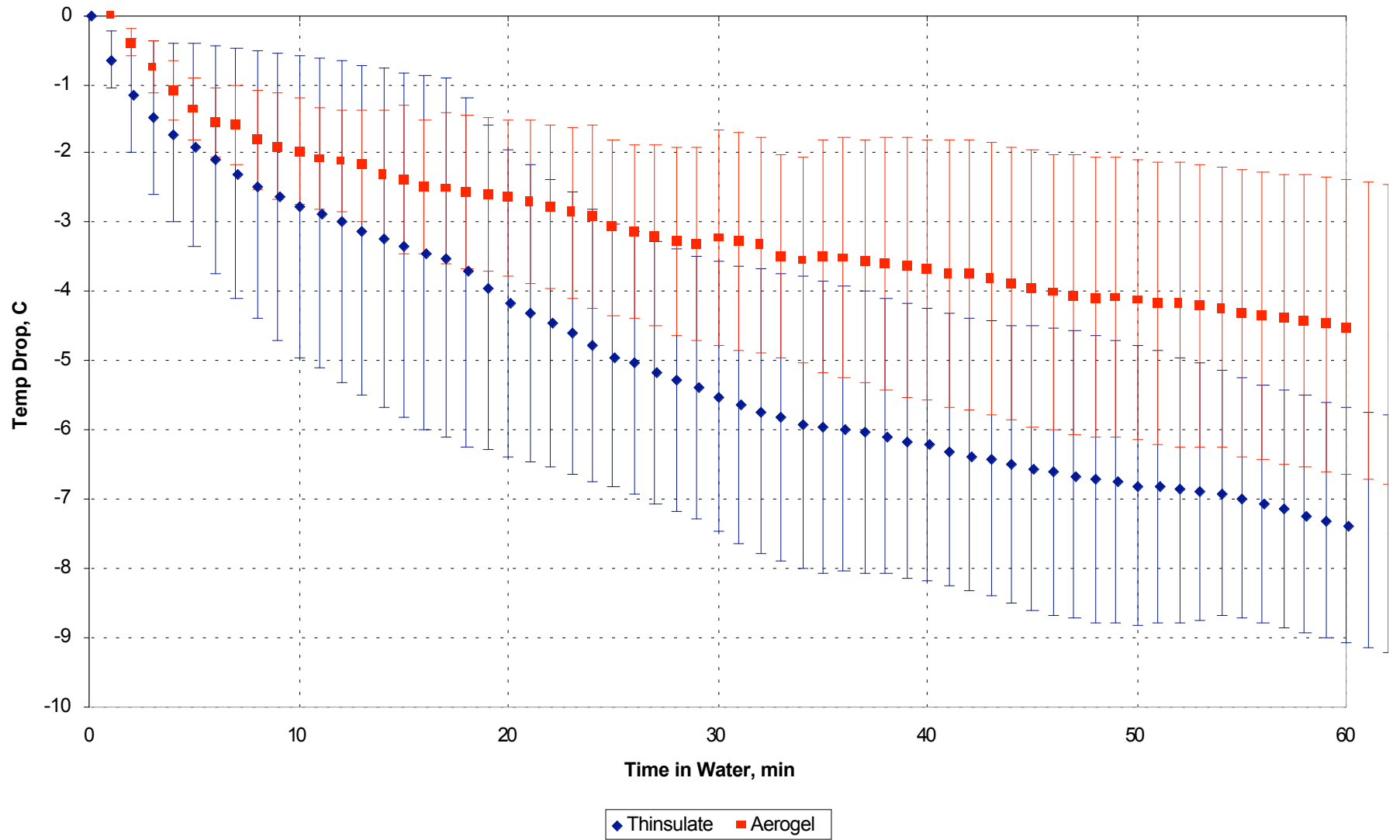
TLS350 Drysuit

POOL TESTING



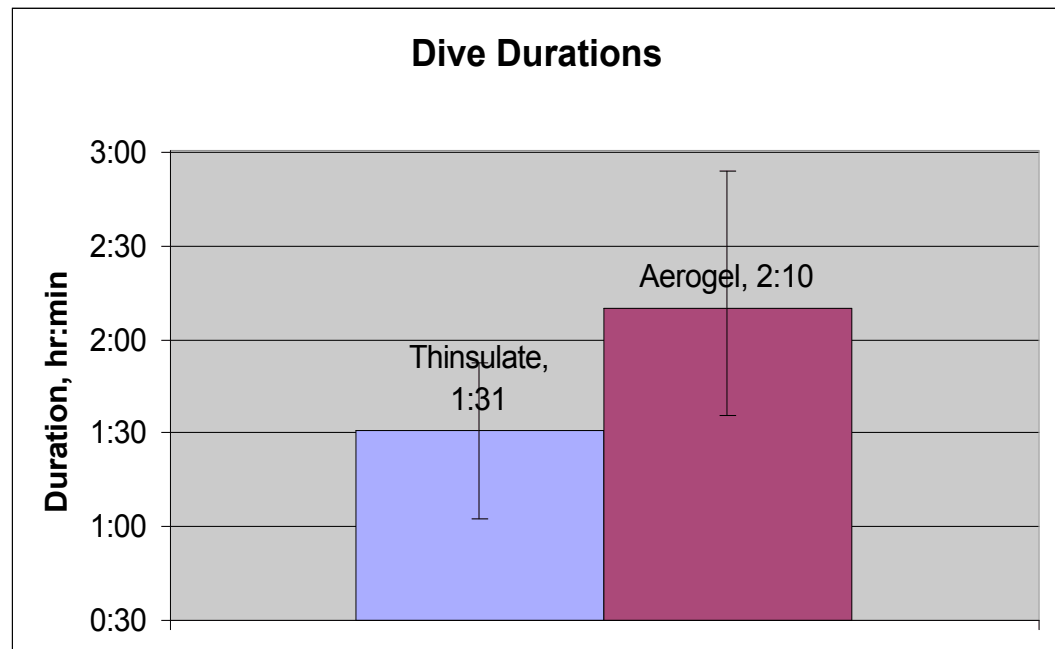
- 6 male Navy divers
- 1.7°F (35°F) water temperature
- Minimal movement
- Aerogel versus Thinsulate
- Abort criteria
 - Drop in core temperature $\geq 1.5^{\circ}\text{C}$ (2.7°F) below baseline for at least 5 minutes or $\leq 35.0^{\circ}\text{C}$ (95.0°F) at any time.
 - A toe or finger temperature $\leq 12^{\circ}\text{C}$ (53.6°F) for at least 5 minutes or $\leq 10.0^{\circ}\text{C}$ (50.0°F) at any time.
 - Upon request of the diver.

Comparison of Mean Skin Temperature Drop



RESULTS

- 69% greater insulation than commercial Thinsulate garments
- All divers extended bottom times (average 43% longer durations)
- 4°C (7.2°F) higher finger temp at one hour
- 4.5°C (8.1°F) higher toe temp at one hour
- 3°C (5.4°F) higher mean skin temp at one hour



CONCLUSIONS

- Significant improvements in thermal protection can be achieved with the use of aerogel super-insulation fabrics
 - Follow-on testing with pre-production garments



- Recent trials using hand calorimeters indicate similar thermal improvements are achievable with aerogel-treated gloves
- Efforts are underway to commercialize aerogel garments

