Advanced Diver Thermal Protection for Head and Feet

UHMS Annual Scientific Meeting 2011

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Fort Worth, TX

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Period of Performance: May 5, 2008 – June 30, 2011

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Project Goal/Hypothesis

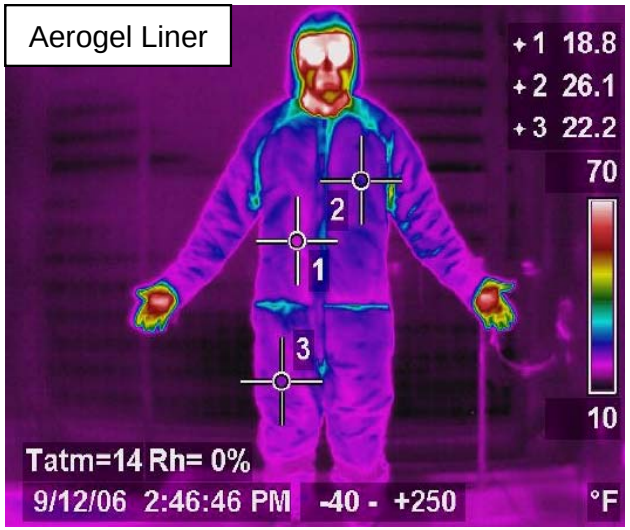
Project Goal:

– Reduce heat loss experienced in a diver's head and feet to maintain comfort and increase duration of cold water dives

Hypothesis:

– Aerogel diving garments increase the duration of cold water dives[1] and the diver's comfort. Cold hands, feet, and head are the most common sources for diver aborts.

– Aerogel's extremely low thermal conductivity coupled with its compression resistance will improve the thermal performance of insulated footwear and headwear at depth, further reducing diver discomfort and increasing the duration of cold water dives. The minimal insulation thickness required will result in minor contributions to buoyancy.



1. Nuckols, M.L., Chao, J.C., Swiergosz, M.J., "Manned Evaluation of a Prototype Composite Cold Water Garment Using Liquids and Superinsulation Aerogel Materials," TA 04-16, NEDU Technical Report TR#05-02, Navy Experimental Diving Unit, Panama City, FL, 7 March 2005

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Fabrication of Aerogel Infiltrated Headwear Liners

Lofted polyester hood fabricated at Aspen

Gel infiltrated hood (solvent not yet extracted)

Aerogel hood with polymer film cover

Hood is encapsulated in finishing fabric

- **Thickness of aerogel hoods is dependent on the polyester liner substrate and on the amount of aerogel infiltrated**

- **The thermal conductivity of the hoods was 12.7 mW/mK; Clo insulation value depends on the thickness of the hood**

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Manned Test Configuration

- **Aerogel hood worn under a latex hood (long)**
- **Aerogel hood did not fit and seal under 7mm neoprene**

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Manned pool test in 55.0 ± 2.0°F (12.8 ± 1.1°C) water

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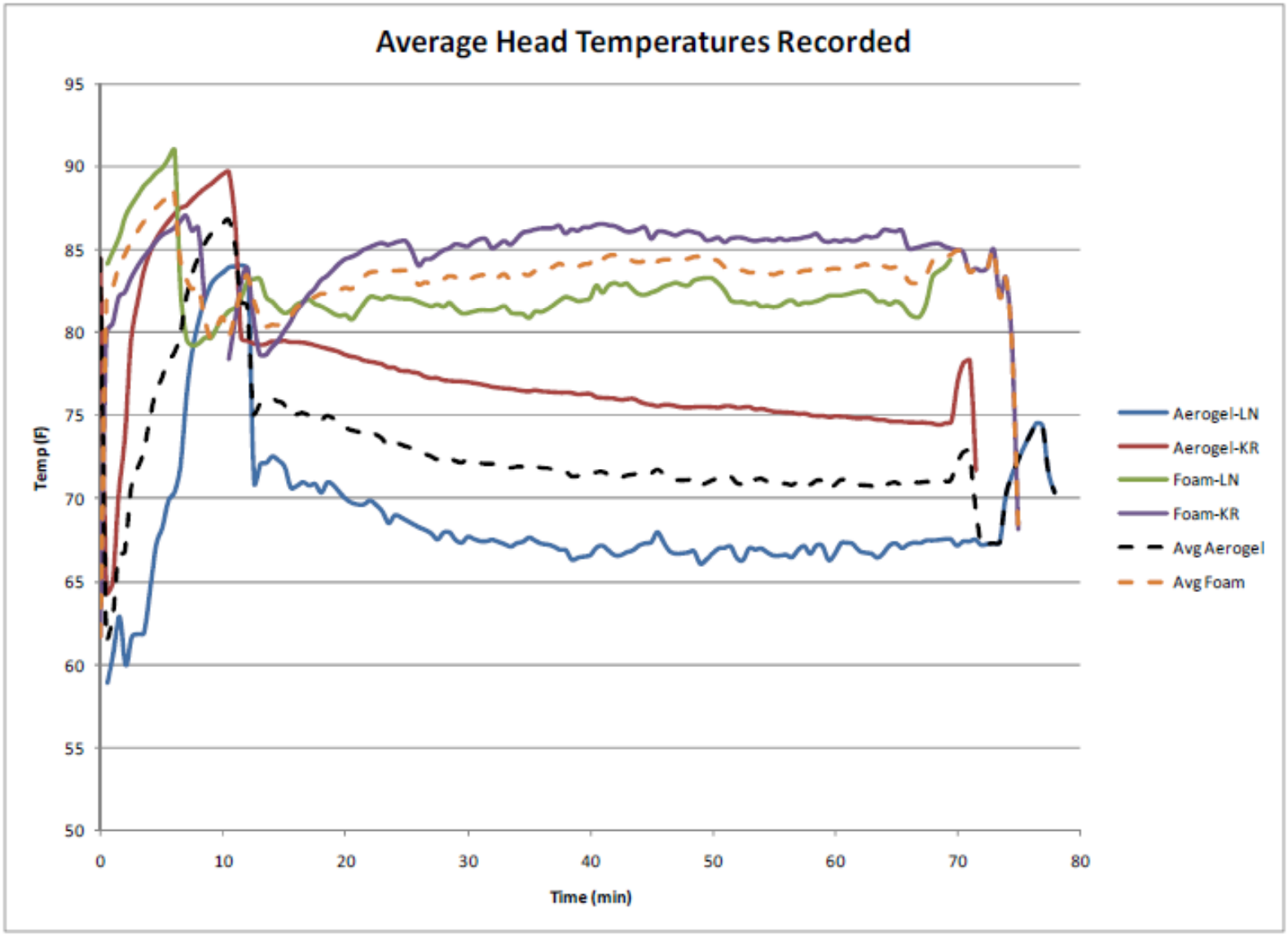
Head Temperatures of 2 dive subjects



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Manned Dive Result - Hood

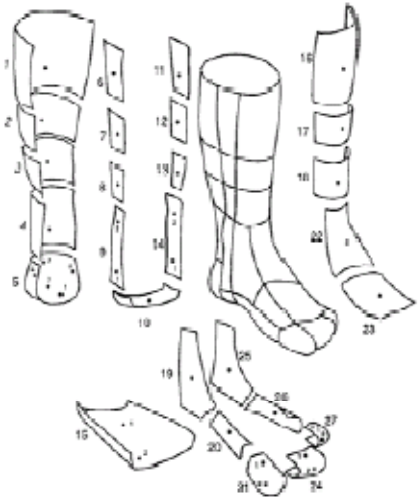
- **Water enters neck seal when head is moved (neoprene or aerogel).**
- **Water enters face seal where mask is worn – Aerogel under latex**
- **Subjects reported being comfortable with neoprene or aerogel hoods**
- **Coldest in face with neoprene or aerogel hood**
- **Data showed head temperatures colder with aerogel hood**
- **Noticeable chilling in chin and cheek areas (Only covered by latex).**

Hood Generation 3

- **More coverage with chin strap**

Immersed Calorimeter Testing

Navy Clothing and Textile Research Facility, Natick MA



Foot Calorimeter

Head Calorimeter

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Hood Solution

7mm neoprene for coverage

Aerogel cap for warmth

Latex hood For seal

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Boot Solution

- **Better fit on calorimeter than Gen 2**
- **Did not fit into commercial bootie**
- **Used over shoe for immersed calorimeter testing**

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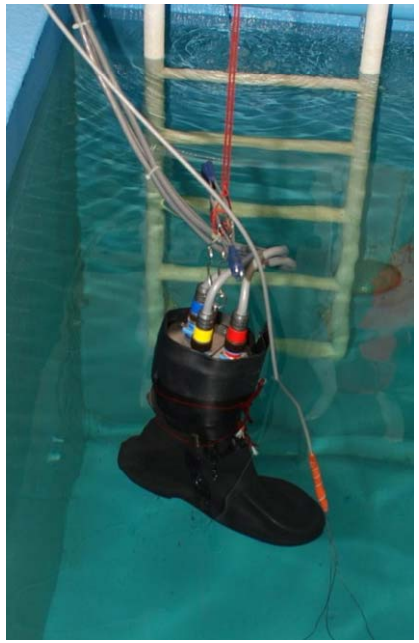
Immersed Calorimeter Testing



- **Encapsulate & seal insulation between the 2 compression layers**
- **Final hood configuration did not seal**
- **Used wrap to prevent water in rushing and determine ultimate Clo value**

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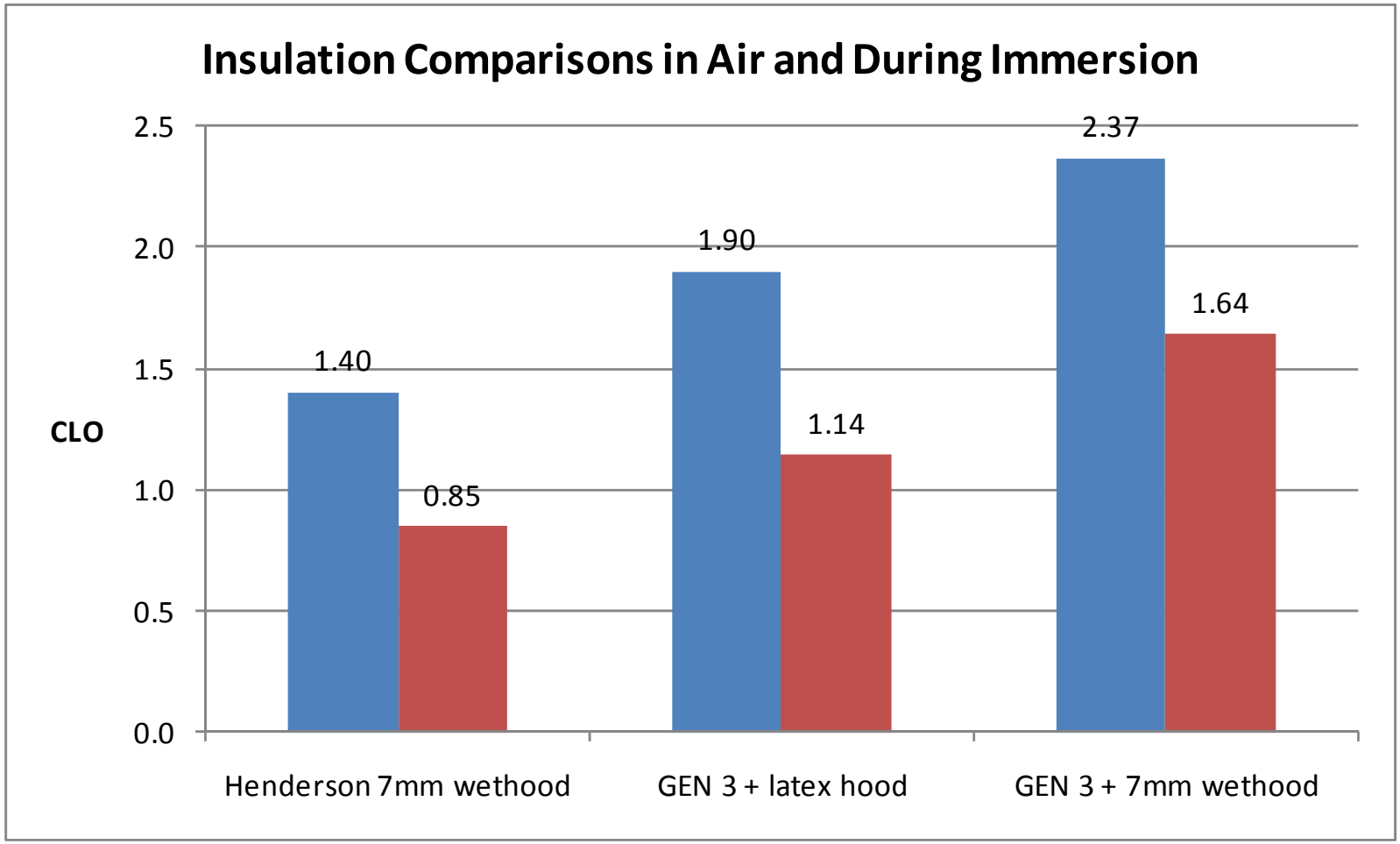
Immersed Hood Result



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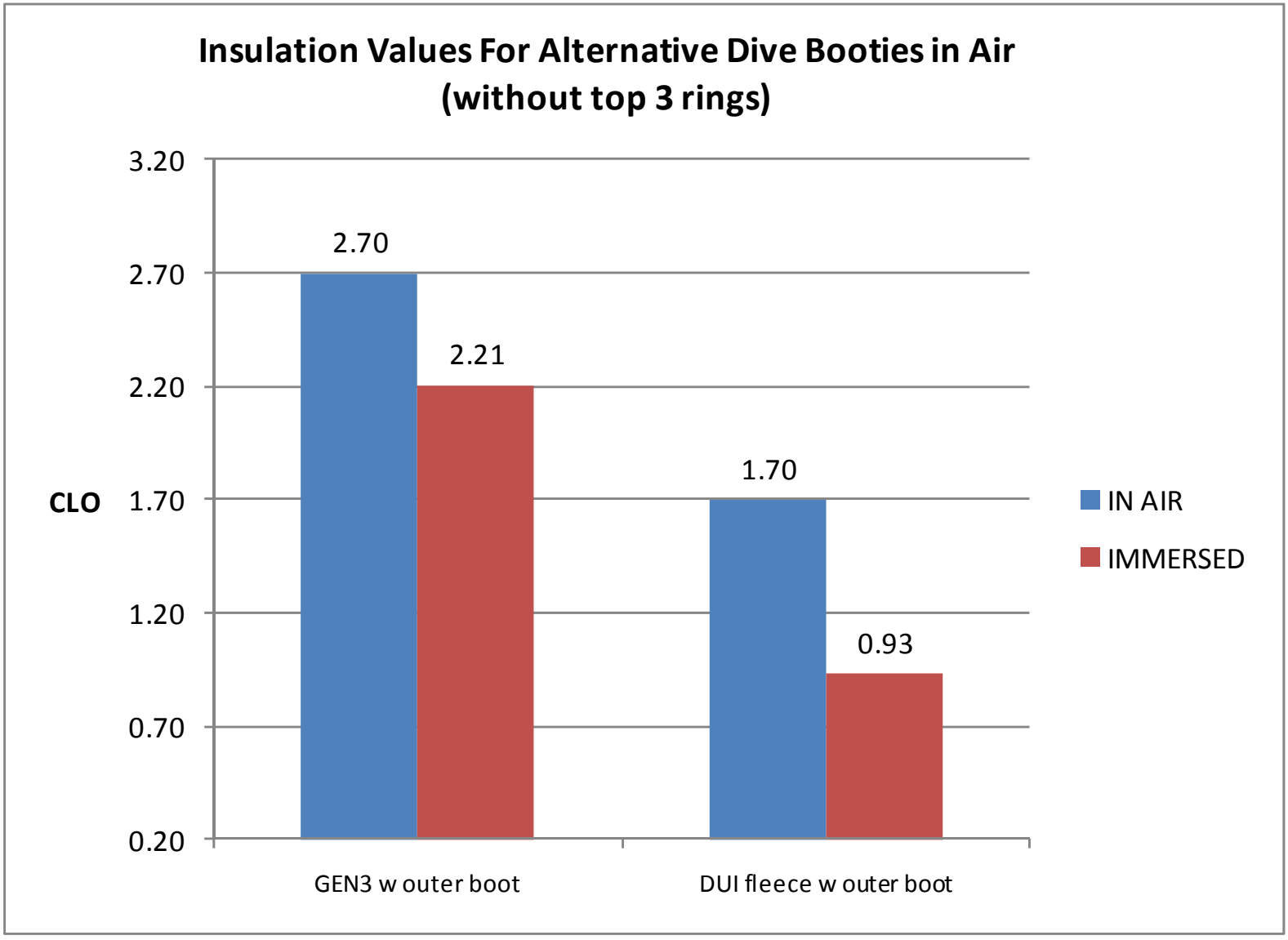
Immersed Boot Result



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Results

Hood

– Obtained excellent Clo values
– 7mm Neoprene & Aerogel - 2.37 Clo value (air), 1.64 Clo value immersed
– Latex & aerogel – 1.9 Clo value (air), 1.14 Clo value immersed
– Aerogel provides insulation but not compressive seal

Boot

– Obtained excellent Clo values - 2.7 Clo value (air), 2.21 Clo value immersed
– Boot did not fit in commercial liner
– Used over boot during testing

Overall

– Superb Clo values but,
– Bulky in design
– Need thinner designs with just enough insulation