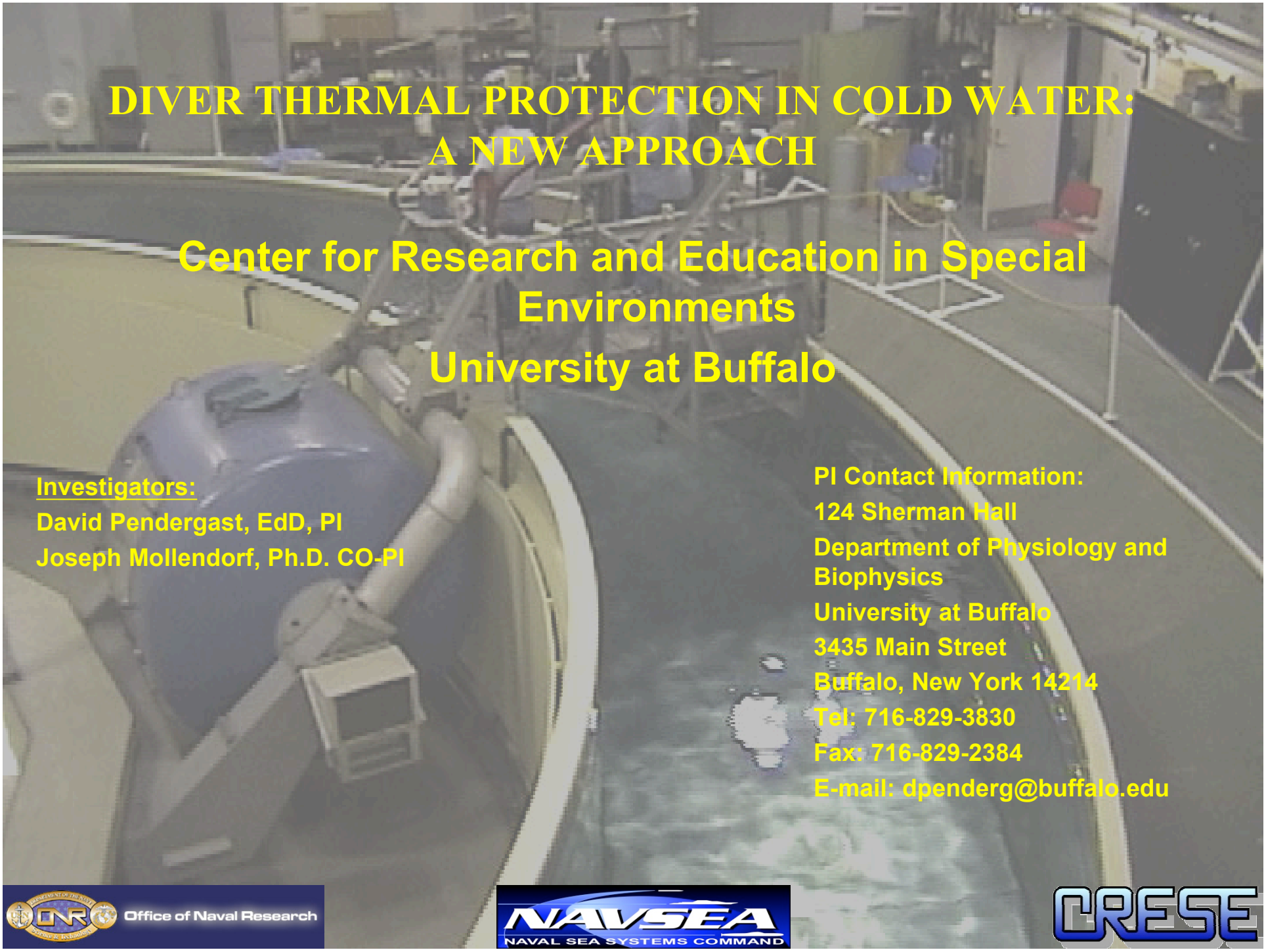


DIVER THERMAL PROTECTION IN COLD WATER: A NEW APPROACH

Center for Research and Education in Special Environments

University at Buffalo

Investigators:

David Pendergast, EdD, PI

Joseph Mollendorf, Ph.D. CO-PI

PI Contact Information:

124 Sherman Hall

Department of Physiology and Biophysics

University at Buffalo

3435 Main Street

Buffalo, New York 14214

Tel: 716-829-3830

Fax: 716-829-2384

E-mail: dpenderg@buffalo.edu

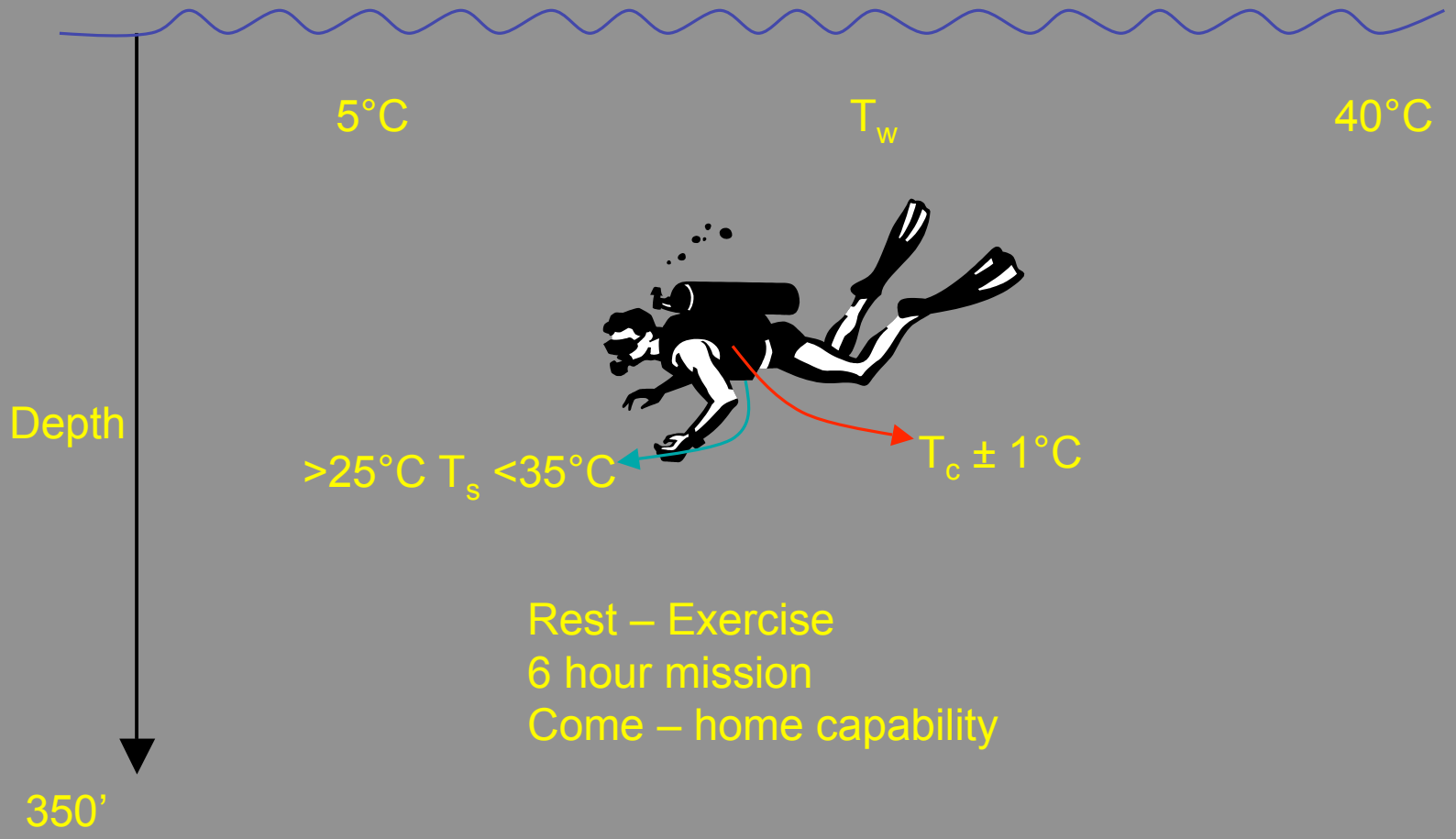
Office of Naval Research

NAVSEA NAVAL SEA SYSTEMS COMMAND

CRESE

AIM: To minimize the impact of thermal issues in dive planning

PURPOSE: To engineer, build and test a Diver Thermal Protection System (DTPS) to meet these criteria.



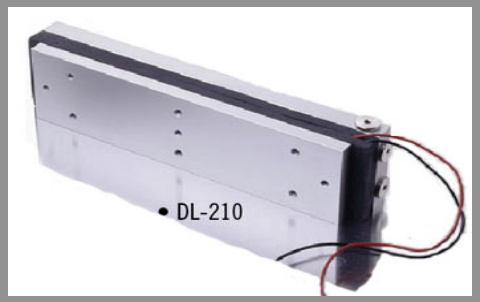
Office of Naval Research

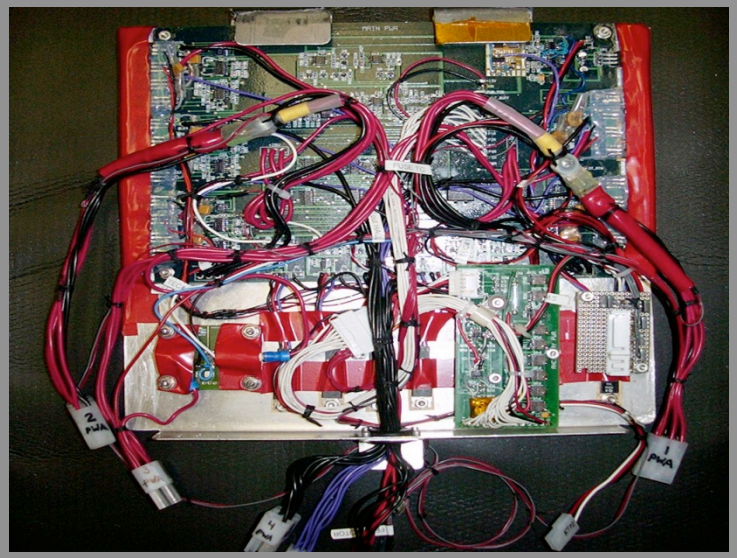
NAVSEA NAVAL SEA SYSTEMS COMMAND

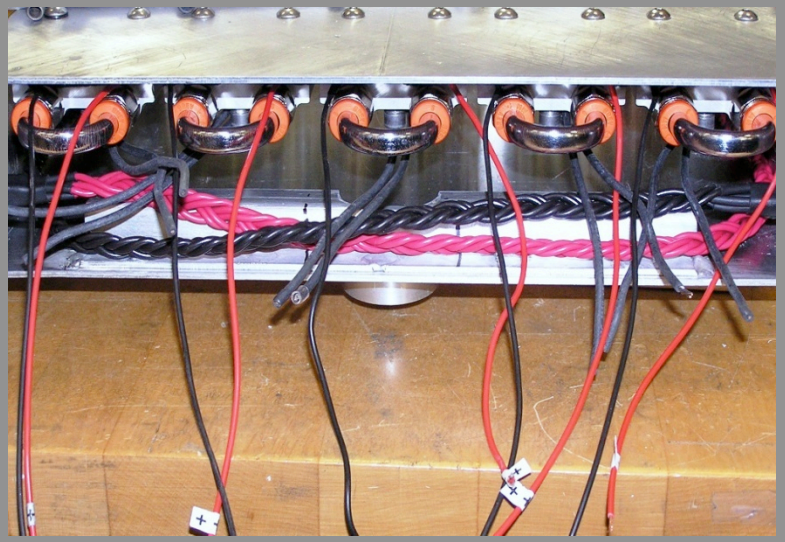
CRESE

Diver Thermal Protection System

Backpack components of DTPS

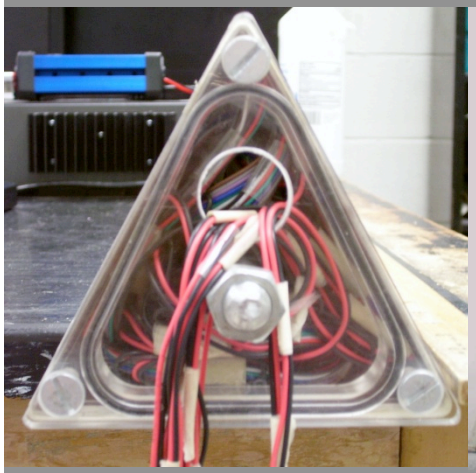


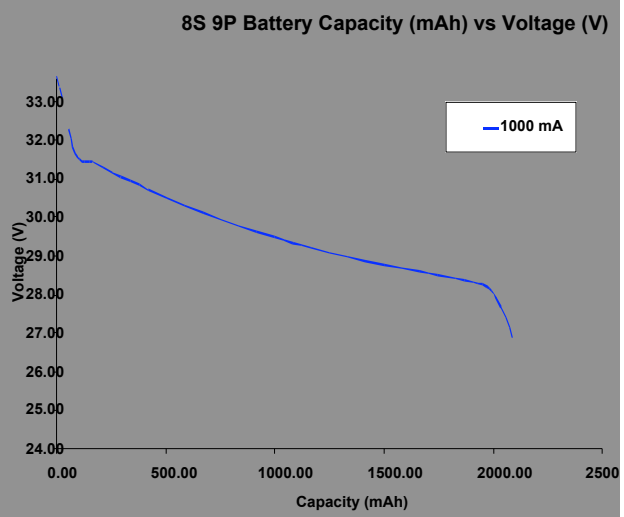




- The left upper panel shows the inlet and outlet manifolds and water circulating pumps that perfuse the tube suit.
- The right upper panel show a single thermal electric heat exchanger that heats/cools the circulating water.
- The right lower panel shows the five TECs and there location in the backpack.
- The left lower panel shows the controller that turns on-off the power to the TECs to heat and cool (duty cycle)

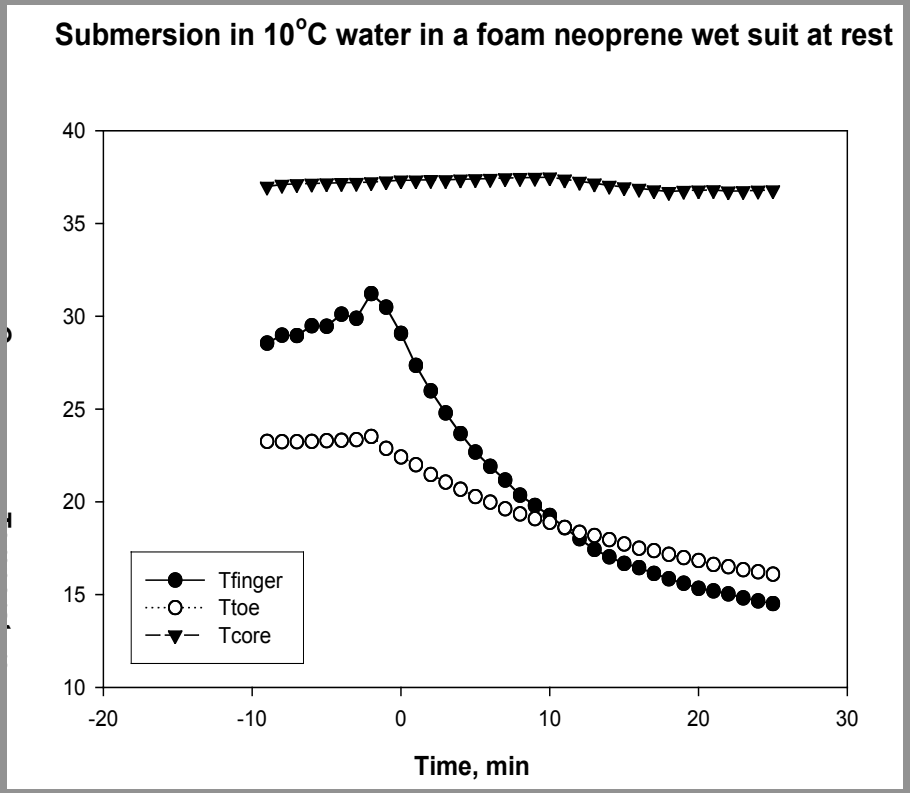
Battery module development, cont.

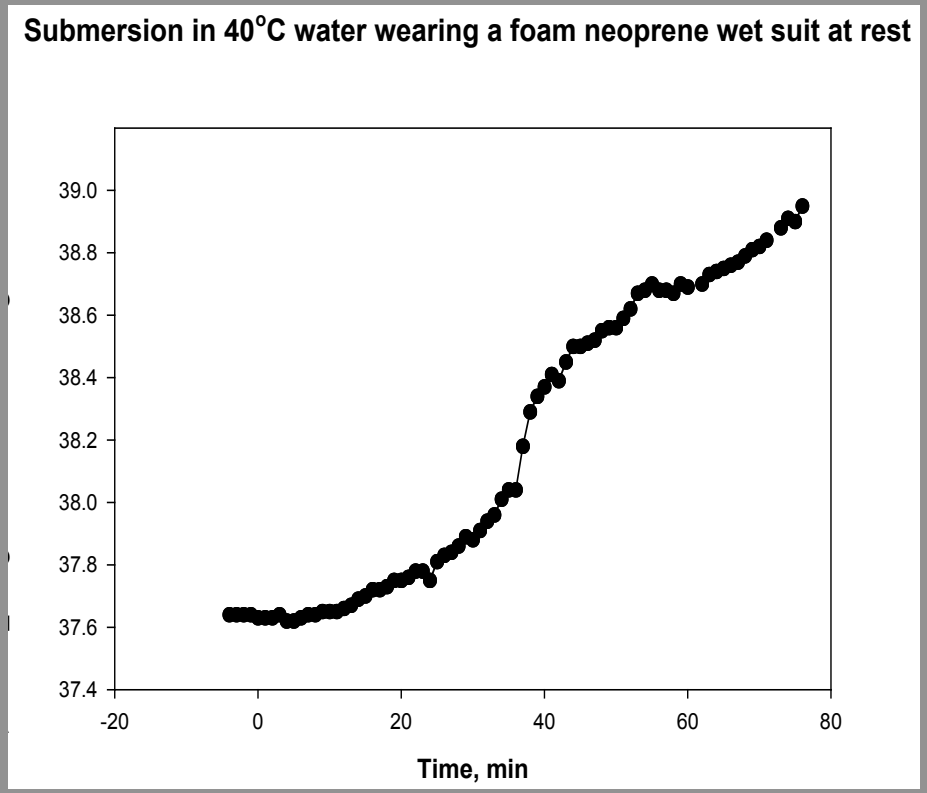




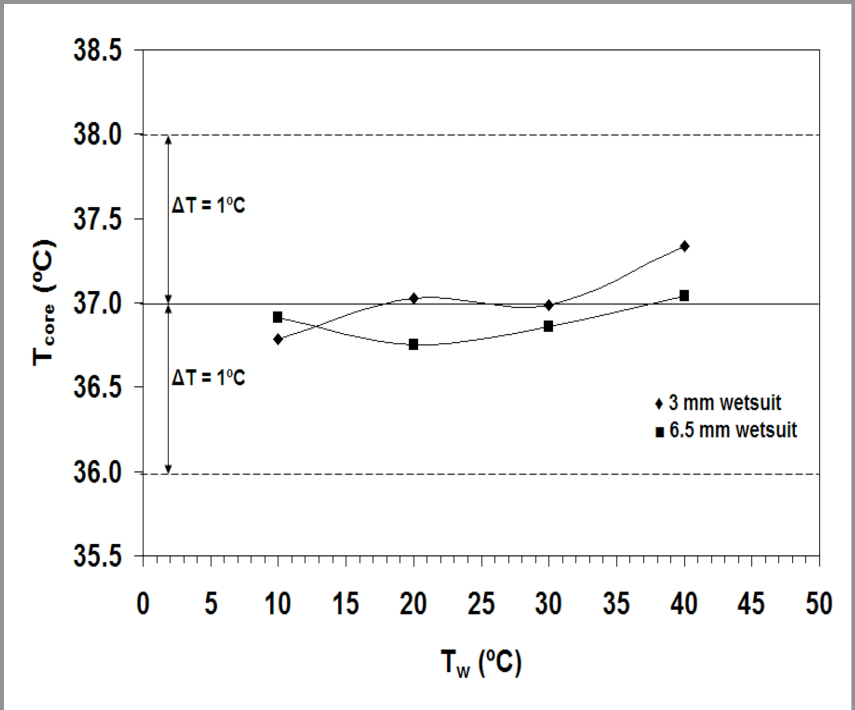
- Left panel shows the nine sticks and protective cards incorporated into a triangular pressure resistance battery module.
- The photo in the middle shows how the battery modules fit on a backpack that also serves to hold two scuba tanks.
- In the right panel the discharge rate that the DTPS will require was used to test the capacity of a single battery module.
- Dive protocols will dictate if the diver is required to carry one or more modules, up to six with out changing the footprint or drag of the system.

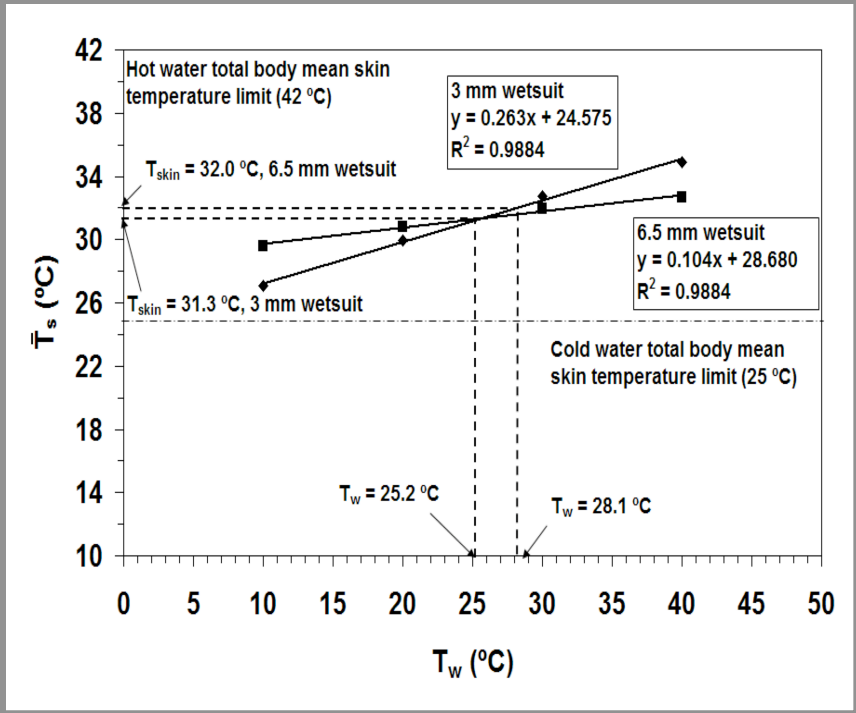
DIVER THERMAL BALACNE
WEARING A FOAM NEOPRENE WET SUIT





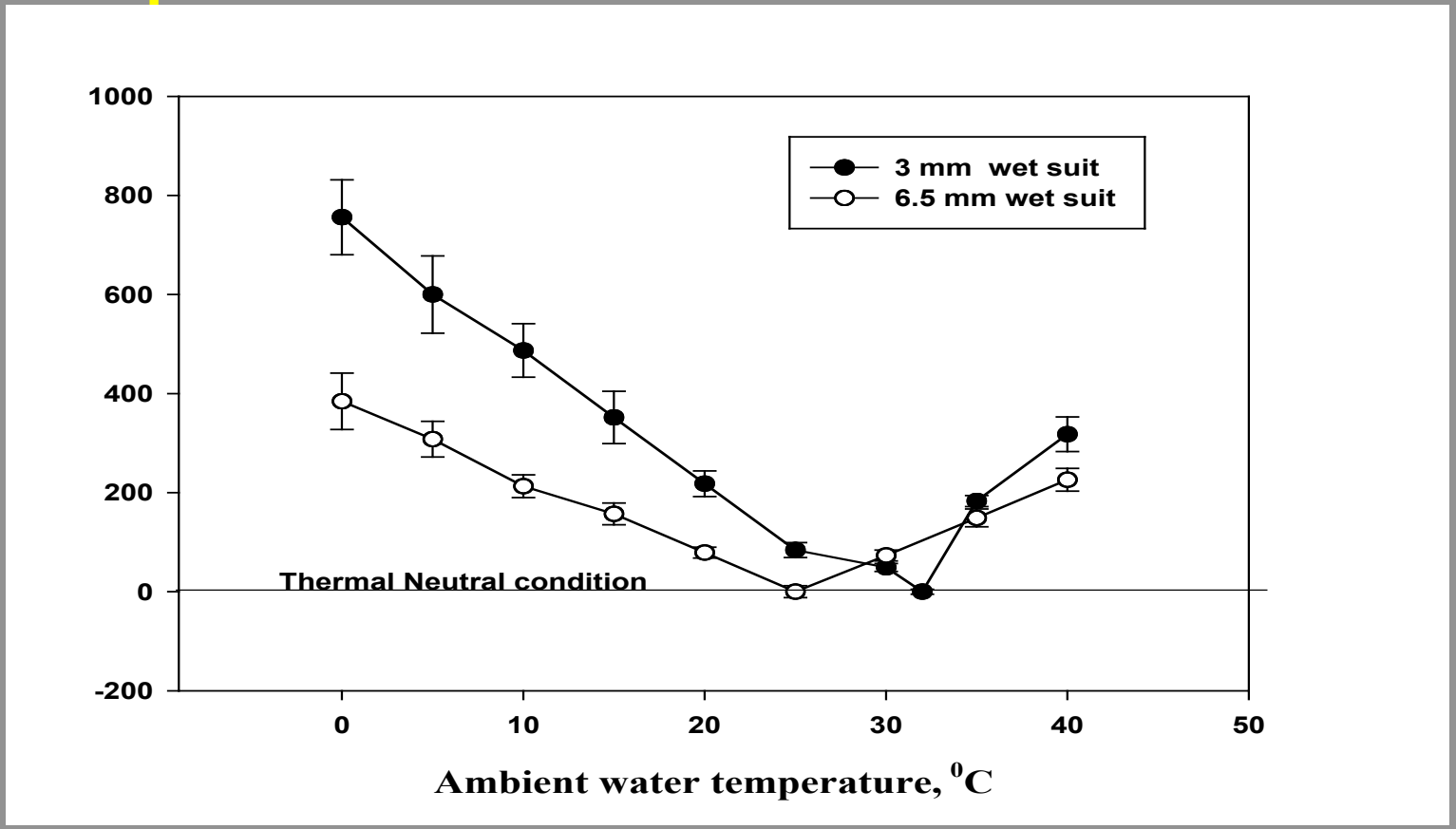
Steady State Body temperatures during submersion with DTPS in water of various temperatures





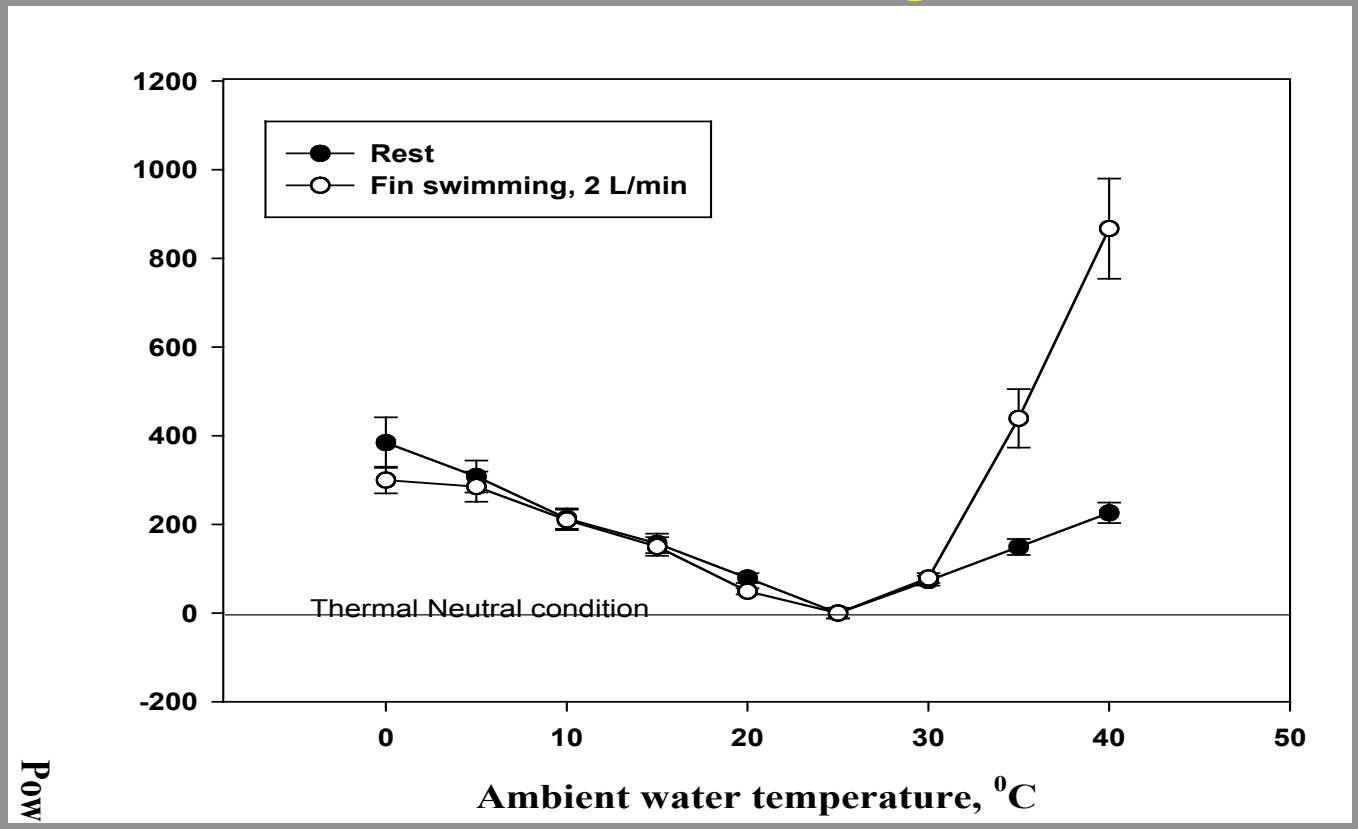
- Core temperature is shown for a resting subject in the left panel demonstrating thermal balance.
- Mean skin temperatures are shown for a resting subject in the right panel.
- Thermal neutral temperatures were 25.2 and 28.1in the 3mm and 6.5 mm wet suits, respectively.
- These data demonstrate the importance of body insulation in thermal protection, even in warm water.

Heating/cooling power required to keep diver thermal neutral at rest



- Heating/cooling power requirement is related to ambient water temperature, low temp. high power or high temp. high power.
- Thermal neutral band (0 power required) at rest = 25-32°C, in agreement with published data.
- Total electrical power will depend on heater/chiller efficiency

Heating/cooling power required to keep diver thermal neutral during fin swimming



- Power requirement is related to ambient water temperature, low temp. high power or high temp. high power.
- Thermal neutral band (0 power required) at rest = 25-28°C
- Thermal neutral band (0 power required) during exercise = 20-28°C
- During exercise in the cold power requirements was not significantly affected, however in the warm it significantly increased the power requirement to keep the diver thermally neutral.
- Total electrical power will depend on heater/chiller efficiency

Summary and Conclusions

- The results demonstrated the efficacy and effectiveness of the Diver Thermal Protection System (DTPS) in providing thermal balance and comfort to the diver in water temperatures from 5 to 40°C wearing a standard wet suit in shallow water.
- The DTPS also protected divers in dives that simulated 50 fsw (3 mm wet suit data).
- Increased insulation reduced the power requirement, even in warm water.
- The power to run the DTPS can be supplied from a variety of sources, including a modular battery system.
- The DTPS can be worn by free swimming divers, without significant increases in oxygen consumption and drag at speeds typical of most dives.
- The power requirement is similar at rest and during exercise in cold water, however significantly greater in warm water, placing increased demand on power.