NASA TECH BRIEF

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Analytic Model for Assessing Thermal Performance of SCUBA Divers

As explorations of the oceans continue, it may be necessary for man to dive to greater depths and stay under water for longer periods of time. Diver performance is in large measure limited by the lack of adequate thermal protection as required for all combinations of diver activity, depth and duration of dive, and ambient water temperatures. To assist the design of adequate protective clothing, a mathematical model of man's thermoregulatory system has been developed so that body thermal responses under immersed conditions can be predicted accurately.

The biothermal model is divided into the physical-controlled system and the dynamic-controlling system. Two types of experimental data were used to substantiate the analytical model: immersed-to-the-neck, seminude subjects in cold-to-temperate water and immersed-to-the-neck, "wet-suit" subjects in cold water. The experimental data encompassed a wide range of water temperatures, protective clothing, breathing-gas mixtures, and durations of immersion.

From the law of propagation of errors, influence coefficients have been derived for 16 parameters that affect the skin and rectal temperatures. These influence coefficients were integrated to obtain four general influence equations for the parameters considered upon the temperatures at rectum, trunk, fingers, and toes. It has been demonstrated that the equations may be used to predict rectal and skin temperatures for various dive conditions represented by small parameter changes around the standard set of values.

The parameters that can be controlled by appropriate engineering design to improve the underwater performance of man in cold water have been identified; other parameters have been shown to be ineffective in preventing rapid cooling of the diver. By use of the various influence coefficients, equations, and the analytical model, any proposed engineering design can be evaluated without need to construct expensive systems or to undertake testing programs with human beings. The model may also be used to assess the endurance and performance of a diver in cold water.

Note:

Requests for further information may be directed to:

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