Keeping the Diver Warm!

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Adequate thermal protection is essential whether one is diving in frigid or warm water. While wet suits, as shown here are still used in cold water operations, they lose much of their thermal protection value when compressed at depth. The thermal protection system being, developed by NCSC is designed around the dry suit concept, with specialized accessories and a layered undergarment that is compression-resistant.

> *Cold is the source of more suffering to all animal nature than hunger, thirst, sickness, and all other pains of life and of death itself put together.*
>
> *Thomas Jefferson*

Inadequate thermal protection is the single most limiting factor for the Navy diver. Moreover, much of the Navy's diving is conducted in cold water, and in situations which preclude surface support and restrict use of fully protective equipment.

The US Navy Diving Manual is clear on the subject of cold:

"As the diver's body temperature is reduced, he will first feel uncomfortable and then ... he will begin to shiver. If cooling continues, his ability to perform useful work may become seriously impaired. The hands lose dexterity and the sense of touch is dulled. As shivering intensifies, it brings on a general lack of coordination ... it becomes increasingly difficult to concentrate, and the ability to think clearly is soon lost. At extremely low temperatures, or with prolonged immersion, body heat loss will reach a point at which death will occur."

But the manual goes on to say that "appropriate dress can greatly reduce the effects of heat loss, and a diver with proper dress can work in very cold water for reasonable periods of time."

Which is what the Diver Thermal Protection (DTP) program at the Naval Coastal Systems Center (NCSC) is all about development and testing of "appropriate dress" to provide the diver with the best thermal insulation possible, and extend the length of time he can perform useful work in cold water.

Genesis of the Program

To do this, the DTP researchers first defined the operational requirements of Navy diving. There included diving modes and depths, mission characteristics, work requirements, dive duration and expected temperature ranges. Meanwhile, a panel of experts on thermal problems convened by BUMED developed a matrix of temperature limits for allowable thermal stress - for example, mean skin temperature must not drop below 77°F.

Using these criteria, NCSC launched a test program designed to evaluate commercial diving suit systems. The basic segments of this program are:

+ Evaluation of suit design and construction by textile engineers at the Navy Clothing and Textile Research Facility.
+ Anthropometric measurements by the Department of Kinesiology at UCLA to determine the range of motion afforded by seven suits.
+ Testing of insulative effectiveness of dry suits at the Army Research Institute for Environmental Medicine using the copper manikin technique.

+ Testing of insulative properties of various suit and undergarment combinations under wet, hyperbaric conditions using the copper manikin (see article on Meet “The Copper Man”)
+ Thermal studies on divers over a range of hyperbaric conditions in selected garment systems, in cooperation with NEDU.
+ Manned tests under simulated mission conditions.
+ Evaluation of gloves and other component equipment, including a joint NCSC/ NEDU program to measure hand and finger dexterity in cold water.

Toward a Basic DTP System

But the prime objective of the DTP program is the development of a basic thermal protection system. To this end, work is currently focused on dry diving suits, with special attention toward:

+ Improving seals and closures.
+ Selection of a good material for the outer garment.
+ Provisions for the containment of urine.
+ Provisions for the absorption of perspiration.
+ Development of an effective undergarment.

The system now being developed incorporates the above items. It is composed of an elastomer-coated fabric which has improved neck seals, wrist seals and entry closure. The undergarment (see accompanying article) is multi-layered and will withstand hydrostatic compression in the diver’s feet and leg regions. A diver urine collection system is being modified from a NASA-developed unit. The new suit system also includes inflation and deflation valves, integrated weight distribution, and dry gloves.

Diver Heater Approaches

NCSC is also developing diver heating systems for use in situations where the practical limit of passive thermal insulation systems has been reached. These active heating systems furnish heated water to the diver. Current approaches include:

+ A propane catalytic heater for the surface-supported diver.
+ A magnesium-oxygen system which burns magnesium wool in oxygen, for the free-swimming diver.
+ A hydraulically-powered system which circulates heated seawater to a PTC and diver at depth. It may also provide improvements over the existing hot water system in efficiency, and a reduction in hose losses and deck space requirements.

A more detailed account of the Diver Thermal Protection program at NCSC can be found in the 1978 Working Diver proceedings available from Battelle Memorial Institute, Columbus, Ohio. The article is titled, “Development and Test of Thermal Protection Systems for the Navy Diver,” by Maxwell W Lippitt.

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David Niven recently saw the film JAWS. The next morning while swimming in the motel pool he spotted a black form lurking under the water. “I was was walking on the water to get out. Then I found it was a maintenance man in a scuba suit fixing the drain,” he said.

(Australian, 16 March 1976)

Anatomy of an Undergarment

NCSC has developed a layered undergarment that is Comfortable, Moisture Absorbent, Compression Resistant at depth, and provides the Dry-Suited Diver with Excellent thermal insulation.

The basic thermal protection of NCSC's new dry suit system will be provided by an undergarment capable of withstanding the compression produced by hydrostatic forces from the chest area to the feet. The undergarment, which is being developed jointly by NCSC and the Naval Clothing and Textile Research Facility, is a composite with a comfort liner next to the diver's skin. A moisture-absorbing layer to contain any sweat produced at higher metabolic rates is applied next.

This layer is followed by a vapour barrier to prevent water vapour from passing through the insulation and condensing on the cold inner surface of the outer garment. This effect, similar to that used in a heat pipe, cold transfer a substantial amount of heat, if allowed, and would basically short-circuit the insulation. A compression-resistant insulation (open-cell foam plastic or a fibrous batting) is located next to the vapour barrier.

The selection of these two materials resulted from an extensive program to identify or develop insulation materials best suited for dry suit undergarments. These materials are being used in patches located over major muscle areas (which are the primary, heat loss sites) and as continuous garments designed to improve mobility and to prevent gross movements of trapped gas due to diver movements.

The material used in the leg and foot areas needs to be more compression resistant than that used in the torso and arm areas, where more flexibility is required. For this reason, consideration is being given to using different materials above and below the waist.

In a dry suit system, a major thermal failure would be sustained should a significant amount of water enter the suit through seal leakage or punctures. This water would be absorbed by the open-cell insulation used in conventional dry suit undergarments, and greatly increase diver heat loss. to prevent his, a material is being investigated which allows the passage of gas to permit pressure equilibration and prevent crushing as depth changes, but which is impermeable to water. Several such materials have recently become available and are being tested.

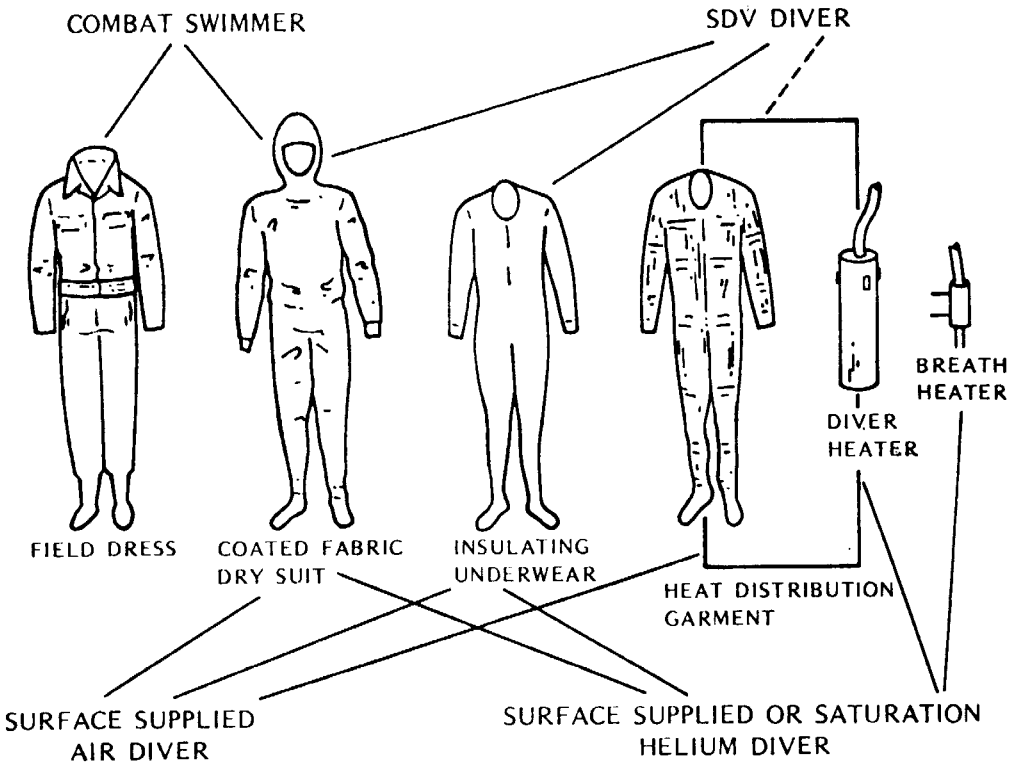
Meet The "Copper Man"

He bears a close resemblance to C3PO in "STAR WARS" but he's really a star in his own right - in what could be called "COLD WARS".

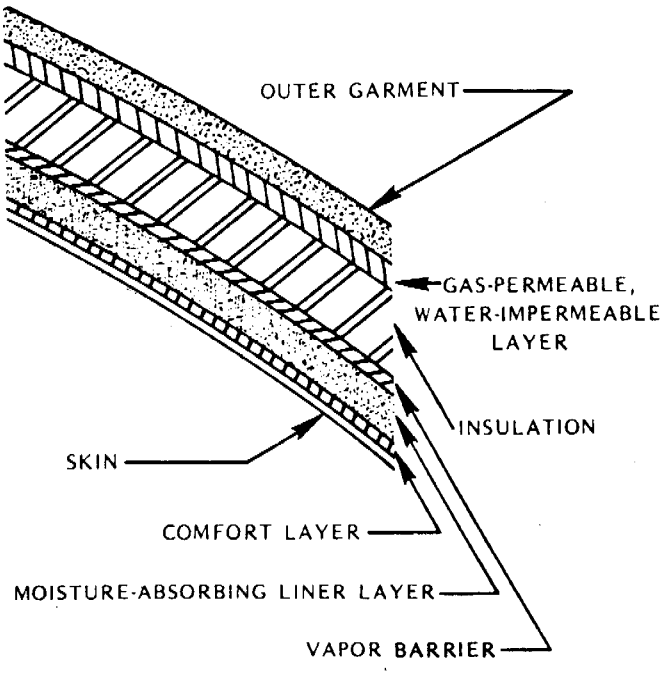
Researchers at the Naval Coastal Systems Center in Panama City have an almost ideal subject for their diver thermal protection studies - one who doesn't mind standing for hours in a hyperbaric chamber, immersed up to his neck in very cold water.

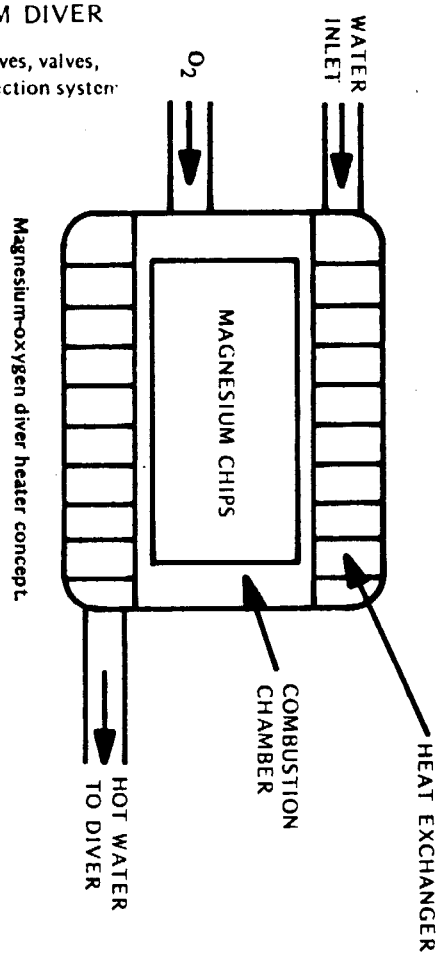
He's the Copper Man, a life-size copper manikin covered with circuits and sensors that allow him to 'feel' the effects of the cold under various test conditions. For a recent series of tests, conducted by NCSC's Diver Thermal Protection Project personnel, the Copper Man was used to determine the insulation properties of several commercial dry suits and undergarments under various hyperbaric conditions. The suits were sized to fit the manikin, and included head and foot protection, plus some specially-designed mittens.

DIVER THERMAL PROTECTION SYSTEM ELEMENTS



NOTE: System will include appropriate accessories such as gloves, valves, weight distribution system, abrasion protection, and urine collection system for each end use.





Because dry suits derive much of their insulation from gas trapped between the diver and suit, each suit was tested with nitrogen and helium as the suit gas.

Through those sensors that simulate skin temperature, the Copper Man revealed the following:

* Neoprene-foam dry suits provide better insulation at shallow depths than rubber-coated elastomer dry suits, but are less effective at greater depths, especially after exposure to high-pressure helium.
* The composition of the gas layer noticeably affects insulation, nitrogen provides the best insulation, followed by helium.
* The insulative value of rubber-coated suit fabric could be increased by improving the undergarment.
* Compression-resistant undergarment materials should be worn, especially in the lower extremities, to offset the effects of pressure at depth.

Although live subjects ultimately remain the best and truest determinants of the value of a given thermal suit, the (‘Copper Man is relieving experimental divers of a great deal of gruelling, cold-water testing. In the battle against the debilitating effects of cold, the diving Navy is fortunate to have the support of the Army Research Institute for Environment Medicine and their Copper Man.

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Institute of Diving

Incorporated under the laws of the State of Florida as a non-profit organisation, the Institute will be international in scope and will act for the advancement of professional, literary, and scientific knowledge relating to human orientated activity in the undersea environment.

Initial activities of the Institute are:

- Establishment of a diving museum and library at Panama City, Florida.
- Publishing a journal which addresses all aspects of diving in a professional yet understandable manner.
- Organisation of a diving information exchange program.

Membership will consist of sport, commercial and governmental divers as well as individuals, organisations and corporations interested in diving or matters diving-related. (Fees are related to membership grouping).

The Institute is the only international organisation which will be solely orientated towards the full spectrum of divers and diving activity. There is no special interest in the Institute except diving. Applications for membership to WN Brumuller, Secretary, Institute Of Diving, PO Box 876, Panama City, Florida 32401. Founder President is Dr George F Bond, Captain MC USN, Retired.

Editor:

We wish the Institute every success. With “Papa Topside” heading the team one can await with complete confidence the impact of this new force in the diving community, not least through its Newsletter.