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Since the Japan Marine Science and Technology Center (JAMSTEC) first carried out an undersea habitat experiment at a depth of 30 m in 1972, over 20 saturation dives have been performed and some interesting data were gathered. Recently a new system was constructed which can descend to 300 m, based on board a newly-constructed double-hull semi-submersible ship. Our target is to establish a new technique for descending to 300 m on the open sea bottom. In this paper, we describe our findings from previous diving experiments, and introduce the outline of a new Deep Diving System and its support vessel.

FINDINGS OF PREVIOUS DIVES

SEATOPIA Project

George F. Bond, Capt., MC, USN, developed saturation diving as a new technique, using the tissue gas saturation theory. This was an epoch-making event, because until that time everyone who engaged in deep diving had difficulty in performing any type of diving operations. Both physicians and divers became enthusiastic and tried to develop methods of diving longer, deeper and safer in conditions all over the world. In particular, the United States, France and the United Kingdom have carried out open sea experiments (Man-In-The-Sea, Conshelf, etc.) since 1962. Japan also followed these tendencies, and prepared a SEATOPIA series of dives as a national research project. JAMSTEC was established as the executive organization under the control of the Science and Technology agency of the government. The goal of the SEATOPIA project was to place four aquanauts in a habitat at 100 m for one month. After several simulated dives, we carried out a 100 m open sea diving experiment in October 1975.

The major findings from the SEATOPIA project were the cardiovascular changes under hyperbaric conditions, measured by impedance cardiography as average transthoracic impedance \(Z_o/L\). We found that, despite bradycardia, the cardiac output was maintained by an increase in stroke volume.
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Additional information was needed on the effects of immersion in cold water at high pressure when breathing a helium-oxygen mixture. Due to the technical difficulties of obtaining continuous information, measurements were undertaken to get the rectal (Tre) and mean skin temperatures (Ts) at 1 and 11 ATA (Atmospheres Absolute) during immersion in 15°C water. The mean skin heat flux (H skin) was calculated from the values of the Heat Flux Transducer under various conditions. The Ts was considerably lower, while H skin was higher, during immersion at 11 ATA compared to 1 ATA. The skin-to-water thermal conductance (Ts - T water/H skin) was nearly three times greater at 11 ATA (20 kcal/h·m²·°C) than at 1 ATA (7.5 kcal/h·m²·°C) (Figures 1 and 2).

Post-SEATOPIA Projects

Following the SEATOPIA project, a series of simulated dives, named SEADRAGON were performed to 300 m, between 1977 and 1984 (Table 1). In addition to the SEADRAGON series, there have also been shallower dives undertaken in which the scientists themselves were subjects. Some 7 ATA dives, using the newly-constructed DDC, were also performed for the purpose of operational training and testing of the system.

On these dives, changes due to hyperbaric diuresis were the most significant. This was noticed during measurement of daily urine volume from divers forced to void periodically. We also observed two different phases of diuresis: one during compression (compression diuresis), the other during holding pressure. On compression diuresis, a significant increase in urine volume was observed on the second day of compression (from 100 to 200 m). On the first day (0 to 100 m) and the third day (200 to 300 m) the change was not significant. Hyperbaric diuresis observed at pressure was associated with an increase in the
fractional excretion of filtered osmotic substances (e.g. Na, K, and urea). The major portion of the increased urine flow at high pressure was due to increased overnight urine output (Figure 3).

THE NEW DEEP DIVING SYSTEM AND DIVING SUPPORT VESSEL

A new multiple-function vessel has been designed, and will be undergoing sea trials, to support the new deep diving operations. For improved stability, and to provide a wider operational deck area, JAMSTEC has decided to adopt a semi-submersible catamaran-type design. A center well is provided to hoist and lower an SDC easily, using "A-frame" cranes near the well and starboard on the upper deck. Umbilical winches are also near the center well, located so that the passing of the SDC does not disturb winch operation. Deck Decompression Chambers (DDC) are located slightly aft of the center well on the main deck. Monitoring and communications are done through a central control panel.

Deep Diving System

The Deep Diving System consists of two SDC sets (spherical and cylinder type), two DDC units, and a transfer lock. The cylindrical SDC is mainly used for lockout diving down to 300 m depth, while the spherical SDC is used for deeper observation research down to 500 m depth under atmospheric environment. Environmental controls inside the chamber can be automatically or manually operated from the central control panel. A TV camera is fitted on each DDC and transfer lock, for monitoring the inside of the chamber.

Dynamic Positioning System

One of the major characteristics of the support vessel is the dynamic positioning system, which can hold the ship's position accurately within a radius of about 5% of operating depth, or 10 m, whichever is greater.

Using this newly-constructed Deep Diving System and the support vessel, JAMSTEC will carry out a saturation dive at a depth of 300 m in the open sea within two years.
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REFERENCES


