Equipment Innovations Cut Risks For Divers in Polluted Waters

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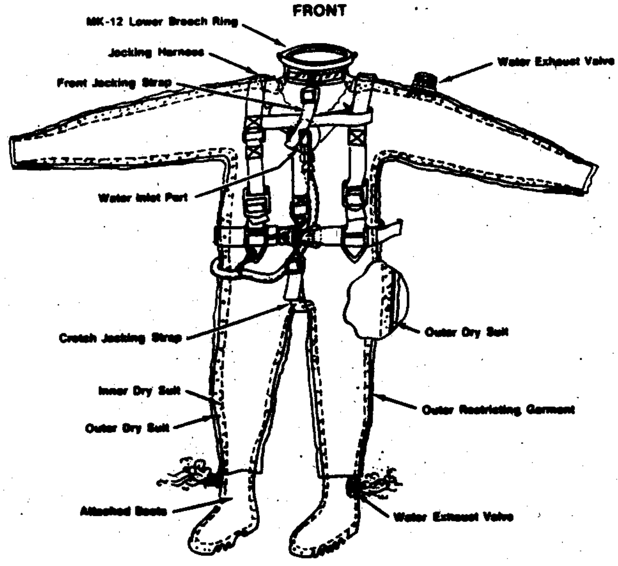
During the last decade, as the number of scientific diving operations in polluted water has increased, the spectrum of materials to which divers are exposed has grown as well. At first, little consideration was given to the possible effects of these materials on the divers themselves. In the early 1970s, for example, diver services were used in studies that examined the fate and effect of sewage and chemicals introduced into the sea. Immunizations against certain pathogenic microorganisms were given in some cases, but illness was reported in some divers who were exposed to sewage. Dry suits and surface supplied diving apparatus with high rates of air flow was believed to offer some protection.

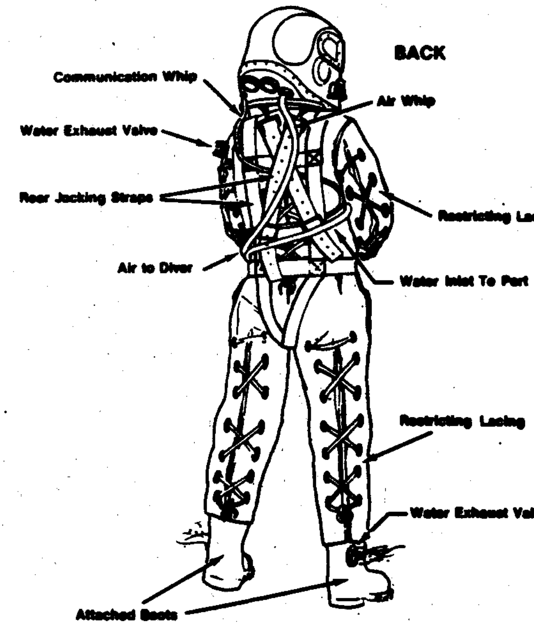
As the list of dangerous substances to which divers were being exposed became larger—and as the substances became more hazardous—attention was focused on the potential threat to diving and support personnel and on the effectiveness of available diving apparatus in protecting divers.

Safety Studies Begin

During the mid-1970s, the National Oceanic and Atmospheric Administration (NOAA), the Naval Medical Research Institute, and the University of Maryland conducted joint studies on the effectiveness of diving equipment in protecting divers from pathogenic microorganisms. Various methods of disinfecting equipment were also evaluated. The early results of these studies are included in the proceedings of the Undersea Medical Society workshop "Microbial Hazards of Diving in Polluted Waters." Later results are published in the open literature.

The diving procedures as well as the equipment selected and developed during these studies provided increased protection for divers, but protec tion for personnel operating in wate containing highly toxic substance and radioactive materials was sti not considered adequate. Sever government agencies and comme cial companies that were required t work in such waters were concerne for the safety of their divers. Thi concern resulted in the formation o an informal working group whos purpose was to pool expertise in a effort to select or develop equipmen and procedures which would protec divers in waters containing hazard ous materials. The Environment Protection Agency (EPA), U.S. Nav U.S. Coast Guard, Department Energy (DoE), Undersea Medic Society, University of Maryland, an NOAA were members of this grou Considerable advice was obtaine from commercial diving companie and funds were provided by the EP DoE, and NOAA.





The twin layers of the positive pressure "suit under suit" (SUS), with an inner foam neoprene neck-entry dry suit worn under conventional dry suit with ankle exhaust valves, give double protection to the diver in contaminated waters and diminish the risk

Initial work concentrated on the structure and funct·on of diving equipment that would effectively isolate the diver and his breathing gas supply from the water. Modifications to available equipment have been required. The problem of overheating has been addressed and progress has been made in this area. Studies of the chemical compatibility of diving equipment and substances which are likely to be encountered are currently being conducted, as is work on retention and permeability.

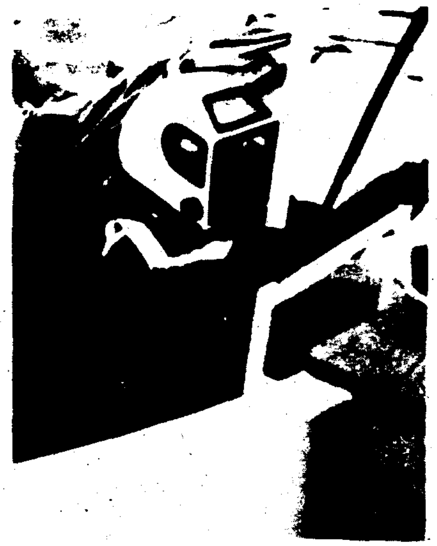
There are several characteristics of commonly used diving equipment that make it unacceptable for diving in contaminated water: foam neoprene dry suits are difficult or impossible to decontaminate; the numerous "breakable" seals on masks, helmets, and suits increase the frequency of leaks; and reliable, dry glove systems are rare. Moreover, exhaust valves in demand regulators allow a few small droplets of water to enter during the exhaust cycle. When the demand valve is activated during inhalation, the jet of incoming air breaks up these droplets into a mist which is then inhaled by the diver. Total encapsulation of a diver can, even in temperate waters, result in hyperthermia. The problem of overheating becomes especially critical when diving in tropical water, or heated water, such as is encountered in cooling water outfalls or inside nuclear reactors.

Equipment Innovations

Solutions to most of the problems related to the structure and function of diving equipment have been found. The problems of compatability and permeability of suit, helmet and hose material by some substances remain to be solved.

Several "smooth" or "slick" skinned dry suits are available. This type of outer surface can be decontaminated in a reasonable fashion. Helmets that attach directly to a dry suit minimize the number of potential leak locations.

The problem of "splashback" through the exhaust valve of demand regulators was solved by installing a "series exhaust valve" (SEV). The SEV is simply a valve arrangement in which two exhaust valves are aligned in series, with a small cavity between the two valves. Using dye tracers, technicians in the NOAA Diving



Wired with heat-sensitive monitors, a diver prepares to enter a solution of heated water, ammonia and fluorescent dye during tests of polluted water diving equipment conducted at NOAA's Experimental Diving Unit.

the outermost valve, but none has ever been detected inside the second valve. The SEVs designed by NOAA are now available on one commercial helmet and on one mask.

The positive pressure helmet, "suit under suit" (SUS) combination, is an an innovative solution to two problems associated with contaminated water diving—thermoregulation and leakage. The SUS consists of an inner, thin,, foam neoprene neck-entry dry suit with attached booties. A conventional dry suit with ankle exhaust valves, and an adjustable pressure arm-mounted exhaust valve is worn over the inner suit. A. "neck dam" installed in the outer suit is clamped to the entrance yoke of the inner sit, thereby creating a closed cavity between the two suits and separating the diver's head from the sits. An outer chafing/re-straining garment is worn over the outer suit.

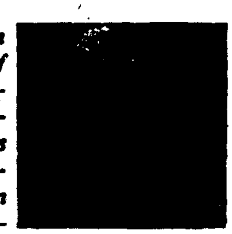
Clean water of the desired temperature (hot or cold) is pumped into the area between the two suits to warm or cool the diver. Since the entire volume of the suit is filled with water under a pressure slightly greater than the outside water, a puncture or leak in the suit results in clean water leaking out, rather than outside water coming in, as is the case with air-filled suits. In the latter, the air pressure below the chest level of a standing diver is lower than the outside water pressure. The insulating quality of the inner suit prevents burning

This type of accident has happened several times with commercial hot water suits.

Contamination Testing

Rigorous testing of this equipment has been conducted at the NOAA Experimental Diving Unit. Equipped with monitoring devices for heart rate, rectal temperature, helmet temperature, and helmet gas contamination, divers have performed work tasks and exercise routines in heated water containing ammonia (as a gaseous tracer) and fluorescent dye (as a liquid tracer). Tenders were dressed in protective suits and equipped with self-contained breathing apparatus. Decontamination procedures were practiced on divers and tenders, and following the dives both were examined with ultraviolet lights to locate flourescent dye. No penetration was found on diving equipment that had been given thorough pre-dive tests. Contamination of tenders was found on several occasions.

The most impressive findings of the tests conducted in the NOAA Experimental Diving Unit came in the heat stress series. One diver experienced significant heat stress at 42°C after a 20-minute period of light exercise in an air-filled suit. Wearing the positive pressure water SUS, the very same diver was able to complete three successive exercise periods at 44°C with no indication of hyperthermia.



Dr. J. Morgan Wells, director of NOAA diving programs, has participated in numerous scientific expeditions and saturation diving programs—beginning with Sealab II *and including diving programs in the Atlantic, Pacific, Caribbean and the Baltic Sea. Prior to becoming director in 1977, Wells was science coordinator for NOAA's Manned Undersea Science & Technology Office. He has been an assistant professor of physiology at the University of North Carolina School of Medicine and a research physiologist at the Institute of Marine Biomedical Research in Wrightsville Beach, North Carolina. Wells received his doctorate in marine biology/*