New equipment makes diving safer in polluted waters

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In the Environmental Protection Agency regional office in Seattle, Washington, there is a mask. A diver's mask. It is a mess, its rubber seal eaten away. The rubber dissolved when a diver from the Seattle Police Department's harbor patrol unknowingly dove into water polluted with hazardous chemicals. Fortunately the diver is all right; he felt a burning sensation and got out of the water fast. He only suffered minor skin burns.

That mask is a graphic symbol of dangers that divers face when they enter contaminated waters. Unfortunately, the need for this kind of diving is on the rise because underwater pollution is on the rise. Between 1977 and 1981, more than sixty-four thousand incidents of petroleum product and hazardous material spills in major waterways were reported to the U.S. Coast Guard. The total number of chemical spills into the nation's waterways, both reported and unreported, is estimated to be about fifteen thousand per year.

Divers who have to enter waters highly polluted with chemicals or pathogens will be better protected by a new suit that has been developed cooperatively by EPA and the National Oceanic and Atmospheric Administration (NOAA). Tests of the SUS (suit-under-suit) equipment show that it can protect a diver from up to 90 percent of the toxic chemicals at underwater dump and spill sites.

As recently as ten years ago, neither the scientific nor the diving communities thought much about the effect of contaminants on divers. It was generally believed, for example, that standard gear offered adequate protection to divers working at ocean dumping sites.

That perception began to change in 1976, when NOAA launched a study of the effects of pathogenic microorganisms on divers in ocean dumping areas. Results showed that "microbial pathogens—bacteria, viruses, and parasites—present in polluted waters clearly pose potential hazards for divers." The results were confirmed by incidents like one in 1982, when several New York City firefighters and police officers became ill after taking part in diving training exercises off a pier in the Hudson River, in a discharge area for raw sewage. They contracted amoebiasis, an infection caused by an intestinal parasite found in polluted water. It was reported that a city sewage treatment plant worker had died of the same disease a year earlier.

The NOAA study was considered at a 1982 Undersea Medical Society workshop sponsored by EPA and NOAA. In an introduction to the proceedings of that workshop, Rita Colwell, a University of Maryland microbiologist, wrote: "The risks [of entering a contaminated aquatic environment] are not known and perhaps not even appreciated . . . Individual working divers are today, more or less, in the category of 'experimental animal' when they enter polluted waters to work."

About fifty divers work for EPA across the country, diving, for example to collect water and sediment samples or organisms for toxicology studies and enforcement investigations. More and more, they are also being asked to dive as a part of Superfund investigations, to confirm toxic spill cleanup results or identify the presence of illegal chemical drums.

EPA's divers often find themselves in some pretty murky waters. "People think we do a lot of Cousteau-type diving, in crystal-clear water," says Don Lawhorn of EPA's Athens, Georgia, lab. "But it's not true. I'd say that on about 70 to 80 percent of our dives, we have zero to very low visibility."

EPA's divers are federally certified through a NOAA program. An interagency agreement between EPA and NOAA addresses development of adequate protective clothing and equipment. "You can't walk into a local dive shop and buy what you need to work in polluted water," explains Lawhorn. The truth of that statement led workers, under the interagency agreement, to a three-year series of test dives to modify available equipment.

Tests began at the Naval Surface Weapons Center in White Oak, Maryland. Seven diving suits and five helmets were evaluated and subsequently modified to eliminate leaks. The first series of tests took nearly a year, from April 1982 through March 1983. Working in a water tower in a hundred feet of water, using a fifty-foot diameter platform that could be raised or lowered to vary the diver's depth, experimenters had tight control over dive conditions.

"We did dive after dive there," says NOAA diver Paul Pegnato. The work did not always progress smoothly. "We didn't follow a straight and narrow experimental path," Pegnato explains. "It was more like a wide, zigzagging road."

But the work paid off. It led to the development of what is, to date, the ultimate in diver protection from contaminants: SUS—the suit-under-suit system.

The SUS system is composed of a tight, one-eighth-inch foam neoprene inner suit and a baggy, heavy-duty, natural rubber outer suit that are clamped together at the neck to form a closed cavity between the layers. Clean, temperature-controlled water is pumped into the cavity through the diver's umbilical hose at the rate of two gallons a minute to warm or cool the diver. The water exhausts through one-way ankle and shoulder valves in the outer suit. Dr. J. Morgan Wells, Jr., director of NOAA's diving program, explains: "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. The suit," says Wells, "is an innovative solution to two problems associated with contaminated water diving: thermoregulation and leakage."

Tests proved that the SUS suit and some commercially available equipment that had been modified did function underwater. The next step was to show that the equipment could really keep out contaminants.

In March 1983, divers tested the modified diving systems at EPA's five thousand gallon chemical dive tank in Leonardo, New Jersey. Fluorescein dye tracers and a simulated spill chemical—ammonia at five hundred parts per million—were added to the water in the tank. Underneath their diving suits, the divers wore special one-piece cotton body suits and carried cotton swabs within their helmets. If contaminants penetrated their gear, the body suit's material would adsorb the dye tracer, which would be revealed under ultra-violet or "black" light. The cotton would become saturated with ammonia, which could be analyzed immediately in the lab. There were no leaks.

During the Leonardo dives, the project crew also began considering other issues related to diving in polluted waters: they developed procedures to protect surface support crews who serve as umbilical tenders and decontaminate emerging divers. (Following cleanup of a 1980 spill of pentachlorophenol in the New Orleans shipping canal, surface tenders had been found to have blood levels of the chemical ten to fifteen times higher than those of divers.)

Next, the heating and cooling range of the SUS suit was tested. At the NOAA Diving/Hyperbaric Training Center in Miami, Florida, in December 1983 and February 1984, divers descended into another tank of water containing fluorescein dye and ammonia. The water was gradually heated to 112°F. Each diver's condition was monitored constantly by electrocardiogram and body core temperature probes; helmet conditions were monitored by additional temperature probes. At each increase in the water's temperature, the divers were to execute a twenty-minute series of exercises.

In the first series of tests, Wells, Pegnato, and NOAA diver Cliff Newell, dove without benefit of the SUS suit's cooling system. After one twenty-minute exercise cycle in 107°F water, Wells' heart rate increased from seventy to one hundred eighty beats per minute, and his body core temperature jumped from 98.6°F to 102°F. "It wiped me out," he says. The other two divers experienced similar dramatic effects of heat stress.

The next day, however, wearing a SUS suit with surface-supplied cool water, Wells was able to stay underwater over an hour and complete three twenty-minute exercise routines with no evidence of heat stress. What's more, he worked in 112°F water, even hotter than the day before, and still emerged "feeling fine."

By this time, the SUS suit, modified versions of two commercially available suits, and two helmets had been identified as effective for diving in contaminated waters. In September 1984, at NOAA's Western Regional Center in Seattle, this equipment was tested under simulated operational conditions. During four-day exercises, divers from NOAA and the U.S. Coast Guard Strike Team, outfitted in the special gear, placed corroded fifty-five-gallon chemical drums into new containers, vacuumed up simulated contaminated sediment and heavy insoluble chemicals, used isolation domes, and carried out welding and cutting operations—all underwater. "Everything went off without a hitch," says Pegnato.

Observing the Seattle demonstration were test engineers from the U.S. Navy's Experimental Diving Unit, which develops and tests the latest diving dress and equipment used by the military. After witnessing the performance of the modified helmets and diving dress, especially the SUS suit, the engineers commented that the work done by EPA and NOAA under the interagency agreement had catapulted diving technology ten years into the future.

EPA and NOAA are now waiting for a "spill of opportunity" to test the SUS suit under actual field conditions. A lower level of diving dress protection was used in December 1984, when the agencies cooperated in a search for leaking drums of toxic wastes at Big Gorilla, an abandoned, open pit coal quarry near McAdoo, Pennsylvania. The SUS suit was not used then because the pollution level had been checked and was not high enough to warrant the new suit's full protection.

The SUS suit has potentially important applications beyond its use in polluted-water diving. For example, the water in the cooling pools that surround nuclear reactors and in the canals at nuclear generating facilities that are used for cooling process waters is extremely hot, between 100°F and 120°F. Commercial divers in cold water SUS suits could perform underwater repairs in this superheated water, eliminating the need to drain the facilities first.

SUS suits also could be used for dives in extremely cold water. For example, rescue workers in warm water SUS suits could stay in icy water for extended periods of time if necessary. In fact, says Wells, the SUS suit will have a working range of 100 degrees: it will warm divers in below-freezing water as cold as 30°F, and will cool them in water as hot as 130°F.

Based on their work under the interagency agreement, EPA and NOAA will publish a manual of practice on operations in contaminated water. An Interim Protocol manual is already available through the National Technical Information Service in Springfield, Virginia. Diving contractors engaged in underwater emergency response and salvage operations should become familiar with the NOAA/EPA procedures and protocols. Work for these contractors is expected to increase, as they take on jobs formerly carried out by the U.S. Coast Guard National Strike Team Dive Unit, disbanded March 1986 in a cost-cutting move. Under new federal safety regulations, employees of such companies must receive training and protection against hazardous substances by this May. Private industry has picked up on some of the innovations pioneered by EPA and NOAA. Four manufacturers are now offering polluted-water diving suits and helmets.

Lawhorn echoes the views of many divers when he talks about the development of protective equipment. "Often you don't know what is being put out upstream," he says, "and you can't find out, without going into the water. When you don't know the conditions, you need maximum protection."