Safe Diving in Polluted Waters

by Susan Tejada

In the EPA regional office in Seattle, there is a mask. It is a diver's mask, and 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.

That mask is a graphic symbol of the 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 64,000 major waterway spills of petroleum products and hazardous materials 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 15,000 per year.

A new type of equipment promises to provide greater protection to polluted water divers than they have ever had before. The SUS suit (suit-under-suit), developed cooperatively by EPA and the National Oceanic and Atmospheric Administration (NOAA), safeguards divers in waters highly polluted with chemicals or pathogens. Tests have shown that the SUS suit can protect a diver from up to 90 percent of the toxic chemicals transported on, or found at, underwater dump and spill sites.

Dangers Recognized

As recently as 10 years ago, neither the scientific nor the diving communities had given much thought to 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 the one in 1982, when several New York City firefighters and police officers contracted amoebiasis after taking part in diving training exercises off a pier in the Hudson River, a discharge area for raw sewage. It was reported that a city sewage treatment plant worker had died of the same disease a year earlier. Amoebiasis is an infection caused by an intestinal parasite found in polluted water.

The NOAA study was examined at a 1982 workshop hosted by the Undersea Medical Society and sponsored by EPA and NOAA. In an introduction to the proceedings of that workshop, Rita Colwell of the University of Maryland 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."

EPA Takes the Plunge

Across the country, in regional offices, laboratories, and on board research vessels, about 50 divers work for EPA. The number has remained fairly steady for the past decade. None of them is a full-time diver. One is a mechanic; others are chemists, biologists, and technicians. They go underwater to carry out their scientific missions—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 on Superfund investigations, to confirm cleanup results or identify the presence of chemical drums.

The type of diving they do can put them 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, Ga., 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."

In 1978, EPA surveyed agency field personnel about their jobs. "We realized," says EPA safety programs manager Tony Brown, "that our divers were doing their own thing. Some had been trained in the Navy or Coast Guard, some by the YMCA. Each had a different set of diving do's and don'ts. The need for an agencywide program was evident."

This need led Brown to NOAA, whose diving program, he says, "was highly accepted in the scientific community. Basically we adopted the NOAA program." EPA now requires its divers to be federally certified, a status obtained by successfully completing a one-week course run by NOAA at the EPA lab in Gulf Breeze, Fla.

The certification program helped ensure diver proficiency, but diver protection remained a serious problem. So in 1982, EPA put more than $500,000 into an interagency agreement (IAG) with NOAA. According to Richard P. Traver, staff engineer at EPA's Releases Control Branch in Edison, N.J., the agreement covers "the assessment, testing, evaluation, and demonstration of modified commercial underwater protective suits, clothing, support equipment, and breathing apparatus in waters contaminated with hazardous substances that may be injurious to a diver's health." Traver, who has been moonlighting as a professional YMCA scuba diving instructor for more than 10 years, was selected as EPA project officer. His counterpart at NOAA was Dr. J. Morgan Wells, Jr., director of that agency's diving program.

Test Dives

"You can't walk into a local dive shop," explains Don Lawhorn, "and buy what you need to work in polluted water." The truth of that statement led workers under the interagency agreement to a three-year series of test dives to modify available equipment.

The tests began at the Naval Surface Weapons Center in White Oak, Md. Seven diving suits and five helmets were evaluated and subsequently modified to eliminate leaks. This first series of tests took nearly a year, from April 1982 through March 1983.

A 50-foot diameter platform within the 100-foot deep water tower at White Oak that could be raised or lowered to vary the diver's depth gave experimenters tight control over dive conditions. "We did dive after dive after dive there," says NOAA diver Paul Pegnato. The work did not always progress smoothly. "We didn't follow a straight and narrow 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: the suit-under-suit (SUS) system.

Basically, the SUS suit is a tight, 1/8 inch foam neoprene inner suit and a baggy, heavy-duty, natural rubber outer suit which are clamped together at the neck to form a closed cavity between the suits. Clean, temperature-controlled water from the surface 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, and exits through one-way ankle and shoulder exhaust valves in the outer suit. Wells 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

(Tejada is Associate Editor of EPA Journal.)

problems associated with contaminated water diving—thermo-regulation and leakage."

Next Step

The test divers at White Oak had shown that the SUS suit and certain commercially available equipment that they had modified did function underwater. The next step was to show that the equipment could really keep out contaminants.

In March 1983, Traver and five NOAA divers tested the modified diving systems at EPA's 5,000 gallon chemical dive tank in Leonardo, N.J. Fluorescein dye tracers and a simulated spill chemical—ammonia at 500 parts per million—were added to the water in the tank. Underneath their outer diving dress the divers wore a special, one-piece cotton body suit and carried cotton swabs within the helmet. If contaminants penetrated their gear, the body suit material would adsorb the dye tracer, which would then be revealed under ultra-violet or "black" light, and the cotton would become saturated with ammonia, which could be immediately analyzed in the lab.

Result: None of the systems tested leaked.

During the Leonardo dives, the project crew 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. They also developed methods to communicate with divers underwater via special microphones placed in the helmets.

The heating and cooling range of the SUS suit was the next item on the testing agenda. At the NOAA Diving/Hyperbaric Training Center in Miami, Fla., in December 1983 and February 1984, divers descended into a tank of water that was gradually heated up to 112°F. Each diver's condition was constantly monitored by electrocardiogram and 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 20-minute series of exercises.

In the first series of tests, the three volunteers—Wells, Pegnato, and a third NOAA diver from Woods Hole, Mass.—dove without benefit of the SUS suit's cooling system. After performing one 20-minute exercise cycle in 107° water, Wells' heart rate increased from 70 to 180 beats per minute, and his body core temperature jumped from 98.6° to 102°. "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,

Jack Stringer

To test the cooling capacity of the SUS suit, a diver enters a tank of hot water at a Miami, Fla., facility of the National Oceanic and Atmospheric Administration (NOAA).

Wells was able to stay underwater over an hour and complete three 20-minute exercise routines with no evidence of heat stress. What's more, he did so in 112° water, even hotter than the day before, and still emerged "feeling fine."

By this time, the SUS suit and 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, Wash., this equipment was tested under simulated operational conditions. In four-day exercises, divers from NOAA and the U.S. Coast Guard Strike Team who were outfitted in the special gear moved 55 gallon chemical drums underwater, vacuumed up simulated contaminated sediment, used isolation domes, and carried out welding and cutting operations underwater. "It was a pretty big shindig," says Pegnato, "and everything went off without a hitch."

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, diving dress, and especially the SUS suit, the engineers commented that the work done by EPA and NOAA under the interagency agreement had catapulted diving technology 10 years into the future.

EPA, NOAA, and the Coast Guard are now looking for a "spill of opportunity" to test the SUS suit under actual field conditions. A lower level of diving dress protection was used last December, when the three agencies cooperated in a search for leaking drums of toxic wastes at Big Gorilla, an abandoned, open pit coal quarry near McAdoo, Pennsylvania.

Other Uses

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 110° and 120°. Commercial divers in cold water SUS suits could perform underwater repairs in this superheated water, eliminating the need to drain the facilities first. Interested in this possible use, the Department of Energy supplemented the interagency agreement with an additional $25,000.

SUS suits could be used for dives in extremely cold as well as extremely hot 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° and water as hot as 130°.

Based on their work under the interagency agreement, EPA and NOAA will publish a manual of practice on operations in contaminated water, hopefully by the end of the year.

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. Modifications of other equipment are available if custom ordered.

Don Lawhorn echoes the views of many divers when he talks about the development of protective equipment. "A lot of times you don't know what is being put out upstream," he says, "and you can't find out. When you don't know the conditions, you need maximum protection." □