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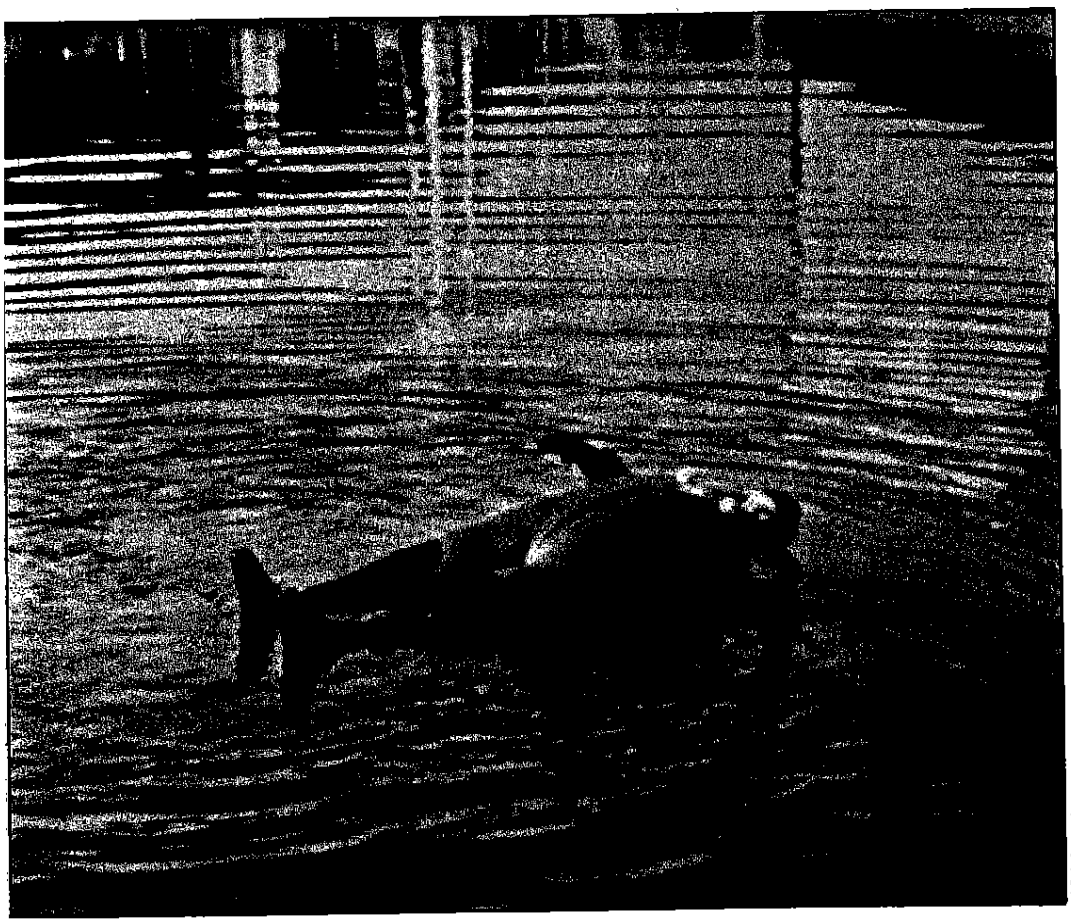
TRAINING DIVERS FOR BLOW-UPS

William J. Brennan



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Bobbing helplessly on the surface (above), the diver who has experienced a blow-up may have ascended too fast, risking a deadly air embolism. With a weight belt still attached, the "blown-up" diver (right) presents an even more grotesque picture.

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Loss of buoyancy control can be extremely dangerous to divers, but knowing what to do in such an emergency can prevent injury or possible death, a special team of NOAA divers has demonstrated.

Increasingly, because of the cold waters and areas of heavy pollution in which NOAA divers must operate, many of the agency's 400 men and women divers are wearing dry suits. Inflated with air or diving gas, these suits keep the diver drier than do the more traditional wet suits. But by their very nature, dry suits enhance the possibility of a "blow-up"—the loss of buoyancy control causing rapid, uncontrolled ascent to the surface.

"Our expanding use of dry suits made it desirable to investigate what might be considered diving folklore concerning blow-ups," Morgan Wells, NOAA's diving coordinator, said. "And we found we could do a lot of things experienced divers said couldn't be done with dry suits.

" 'You'll never pull that off,' we were told. 'You'll wind up on the surface flapping like a toad.' The surprising part is, no one did."

In a week-long exercise conducted at the Naval Surface Weapons Center's Undersea Weapons Tank at White Oak, Maryland, the NOAA team found that with proper training and techniques, an accidental blow-up need not become a life-threatening situation.

Inside the Navy's towering tank a few miles north of the Capital Beltway on New Hampshire Avenue in suburban Maryland, the NOAA team intentionally created blow-up situations in water depths as great as 100 feet.

"This exercise was potentially dangerous and normally would not be

done in open water," Wells explained. "But we felt compelled to duplicate as closely as possible conditions NOAA divers could face during operational activities, and attempt to develop techniques allowing the divers to be in control during a blow-up."

The dozen or so members of the team took with them to White Oak one of NOAA's "portable" recompression chambers in which to recompress divers should that be necessary. The chamber was hoisted to the top of the White Oak tank and temporarily installed there. Emergency use of the chamber was not necessary during the exercise.

One of the most common causes of dry suit blow-ups is loss of neutral buoyancy by a diver accidentally dropping the weight belt, a 30 to 40 pound belt worn to offset the positive buoyancy of the dry suit. Without such weights, a dry suit diver constantly would be struggling to stay at depth to conduct the work schedule.

Monitored by closed circuit television and with a safety diver alongside every moment, members of the NOAA team intentionally dropped their weight belts while 100 feet down in the tank. The normal, and safe, time of ascent from this depth is 100 seconds, following the standard one foot-per-second rate of ascent. In the blow-up situation, however, the divers rocketed to the surface as fast as five times the normal rate rising the 100 feet in only 20 seconds.

Should this occur to an untrained diver, the likely result would be death from an air embolism. The volume of air in a diver's lungs doubles as the diver rises from a 33-foot depth to the surface. Unless the diver controls the volume by exhaling all the way to the surface—thus reducing the volume of air in the lungs—air bubbles enter the blood, block one or more blood vessels, and interrupt normal blood circulation. The effect is the same as a stroke, and therapeutic action in the form of compression in a chamber must be taken immediately to prevent death or serious injury.

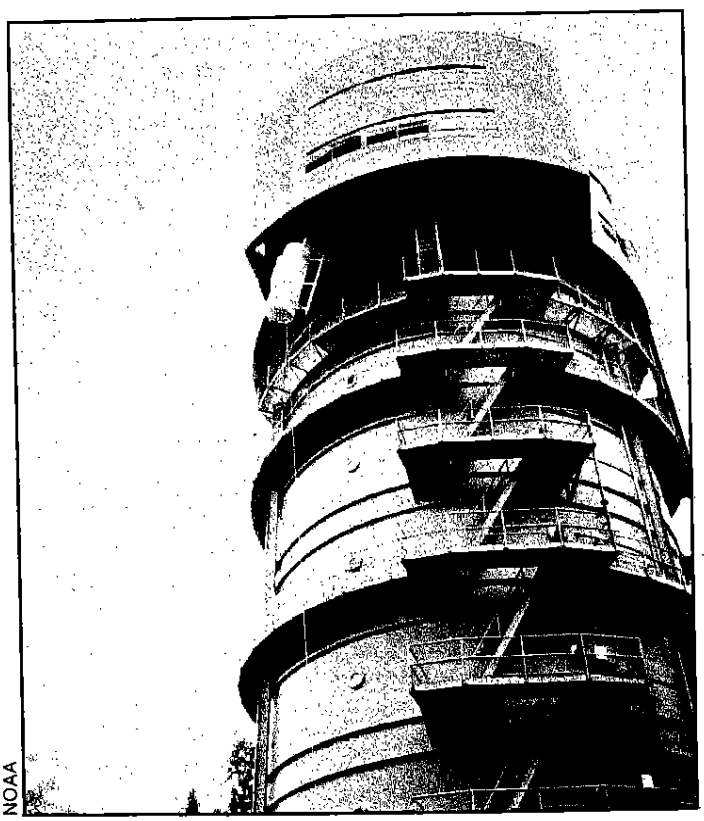
"During a blow-up situation, a diver must know what to do immediately," Wells said. "He or she has to start exhaling and attempt to maneuver into a position that will slow down the ascent rate.

"In a wet suit the diver has much better control over the rate of ascent. In a dry suit the air inside the suit expands as the diver rises, increasing the diver's buoyancy, and speeding up the ascent to the surface. This, in turn, increases the volume of air in the lungs at a faster rate."

NOAA diver Cliff Newell of the National Marine Fisheries Service Woods Hole Laboratories in Massachusetts,—a White Oak team member—faced this problem once during his career. Working at about 100 feet, he had increased the buoyancy of his suit to aid him in moving clumps of cement blocks from one location to another. Using a suit's positive buoyancy to assist in lifting heavy objects underwater is sometimes done by working divers. But it can have dangerous consequences, and it did this time. Newell lost his neutral buoyancy and slowly began rising.

The normal solution, according to Wells, would be to vent the suit, decreasing the buoyancy. Both of Newell's hands were holding the cement blocks, however, and he knew if he let go with even one hand—which he must do in order to vent—he would drop the blocks and rocket to the surface as a result of his increased buoyancy.

Newell did the only other thing possible, exhaling continually as he rose in the water. As the water pressure around him decreased, the volume of air in his suit increased, causing it to balloon. Only his awareness of the need to reduce the volume of air in his lungs by exhaling prevented his lungs from ballooning like his suit and probably causing an embolism.



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A recompression chamber is hoisted to the top of the huge Navy tank (left) in which NOAA divers tested emergency techniques. The chamber (above), being inspected by some of the participants in the NOAA tests, provided an extra margin of safety—fortunately not needed.

As it was, the only damage to Newell was to his pride. By the time he reached the surface his suit had ballooned to more than three times its normal size and he floated helplessly on the surface until retrieved by tenders.

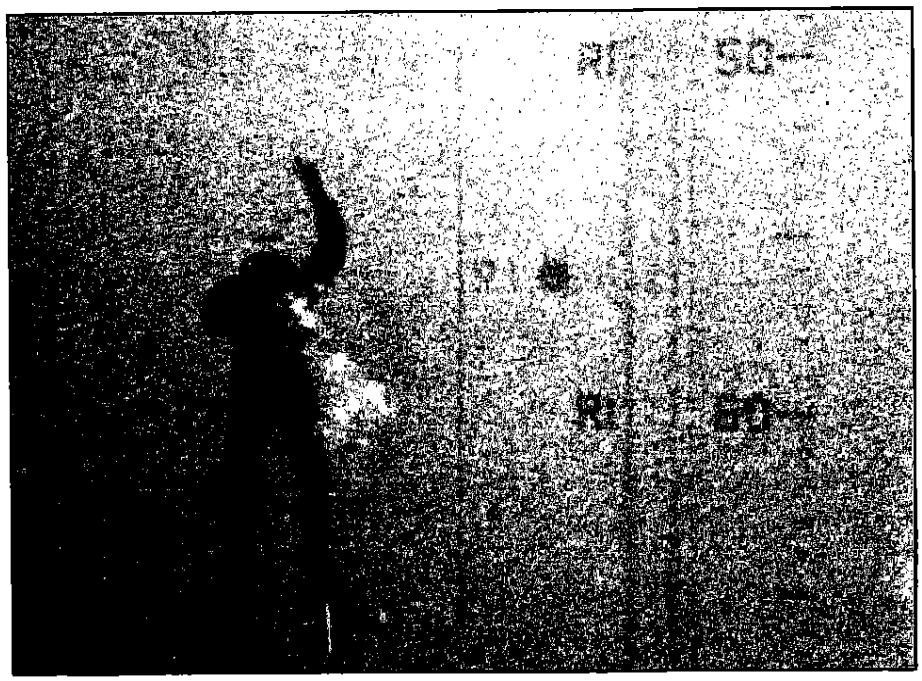
Dry suits have both an air supply valve and an exhaust valve. The supply valve in some suits is connected to the diver's air supply for inflation, while in other suits the diver must inflate them orally. The exhaust valve allows the diver to release air from his suit.

For the valves to do their jobs, as one NOAA diver learned, the diver must be able to control them. Sometimes, this isn't as simple as it sounds. The NOAA diver, on a work assignment beneath the surface, was wearing a chest-mounted "horse collar" buoyancy compensator; a harness-like life vest often used in concert with air in the suit to help a diver compensate for changes in buoyancy while working at different levels.

On this occasion, the NOAA diver chose to increase slightly the amount of air in his suit to change his buoyancy, rather than using the buoyancy compensator. He slipped his hand under the compensator harness and pressed the suit's air inlet valve. Instantly his suit began to inflate as air surged into it, pushing the back of his hand against the harness. He tugged, pulled, but was unable to remove his hand, still pressed solidly against the inlet valve. His suit ballooned as air flowed into it unimpeded. Shortly, he was bobbing about on the surface, his suit vastly over-inflated.

Again, awareness of emergency techniques prevented a serious, perhaps deadly, conclusion to the episode. The diver exhaled constantly en route to the surface, reducing the volume of air in his lungs and thus avoiding an embolism.

The "worst possible" dry suit blow-up situation for a diver is when he loses buoyancy control while working upside down, a not-uncommon position underwater. The air inside the suit accumulates at the highest point; in an inverted position, in the legs and feet, often pushing the diver's fins off. Before the chest or shoulder-mounted exhaust valve can function properly, the diver must maneuver into a positon letting the air in the suit flow to the chest area.



Closely monitored by television (above), a diver dangerously outraces his exhaust bubbles to the surface — a sign of too-rapid ascent. By assuming a "laid back" position, he is able to slow his ascent (right) as indicated by the bubbles which now appear above him.

Techniques to accomplish this were developed during the White Oak exercise and, additionally, it was learned that if a diver gets into a chest-up, horizontal position, not only can the suit's air be vented properly, but the rate of ascent can be slowed down as the amount of body resistance against the water is increased.

The blow-up exercise called upon the vast experience of a number of NOAA divers in addition to Diving Coordinator Wells and Fisheries' Newell. Among them were Dick Rutkowski, Director of NOAA's Training and Recompression Facility in Miami; and NOAA Corps officers Lt. Stanton Ramsey, Lt. Edward M. Clarke, and Lt. Cdr. Tom Ruszala.

Others were Michael Bergin of NOAA's Pacific Marine Center; Bill High of the Northwest and Alaska Fisheries Center; Robert Bedke and Robert Ellis, both from the Auke Bay Biological Field Station in Auke Bay, Alaska; NOAA photographer John Roseborough; and Barbara Brenkworth of the NOAA Diving Office.

In total, these NOAA divers have almost 200 years of professional diving experience, and in a number of instances have faced emergencies under actual working conditions that, improperly handled, could have taken their lives.

The week-long experiment specifically was to evaluate four different variable volume dry suits for:

- Causes of dry suit emergencies and failures;
- Ways to overcome such emergencies or failures;
- The suits' swimability;
- Flotation characteristics of the suits;
- Accessory equipment;
- Proper training techniques and development of a training curriculum.

Suits tested were the Poseidon Unisuit, the Poseidon Jet Suit, the Imperial Suit, and the Viking Dry Suit. Scores of conclusions and dozens of recommendations resulted from the exercise, many specific to the kind of suit worn and accessory equipment used. In general, however, perhaps the most telling conclusions are that emergency procedures for blow-up can be taught to divers, and that with adequate training divers should be able to respond to all blow-up emergencies, control their ascent rate, and prevent lung overinflation.

In other words, as a result of the NOAA research, a broadly held misconception has been laid to rest, and, it is hoped, the stage has been set for future diver training that could result in fewer accidents beneath the sea.

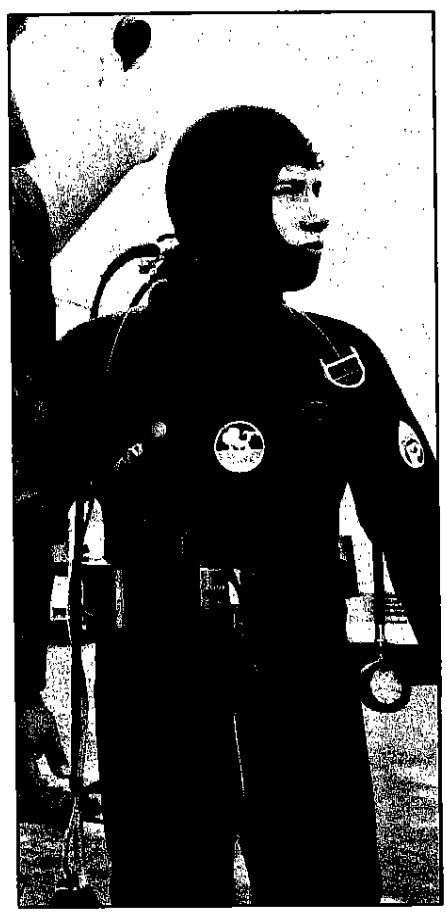
NOAA's exercise with, and testing of, variable volume dry suits contains important lessons to any dry suit diver, professional or amateur.

Possibly the most significant fact to emerge is that while dry suit diving does carry risks peculiar to the equipment used, these are not insurmountable. A diver can experience a blow-up without injury or loss of life, *if* the diver knows what to do in such an emergency.

The research has some pertinent points for dry suit divers:

- Procedures to follow during a dry suit dive can vary depending upon the model suit being worn.
- No one should engage in dry suit diving until having completed a special training course.
- While emergency blow-up venting procedures can be taught, this must be done under very controlled conditions.
- Ankle weights should be worn with dry suits when possible. They help keep the feet down in blow-ups, give stability, and help keep fins on in the event air gets into the suit's feet.
- When possible a quick-release shoulder harness should be worn with the weight belt to reduce the possibility of accidental belt loss.
- Front-mounted buoyance compensators should not be worn with any dry suit that has a purge valve on the front.

NOAA's Diving Office has developed a training curriculum outline for variable volume dry suit diving, applicable to both NOAA and non-NOAA divers.



Compare the fully-equipped diver (left) with those blow-up "victims" on page 1. There are times when an inflated suit is useful, however, as when it is blown-up on purpose (above) to assist in keeping an accident victim on the surface with his face out of the water.