NOAA DIVING PROGRAM
TECHNICAL REPORT 02-01

REPORT ON THE FLOATATION CHARACTERISTICS OF SELECTED DRYSUITS IN A FLOODED CONFIGURATION

By

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October 1, 2002

ABSTRACT

On August 22, 2002, the NOAA Dive Center (NDC) conducted a series of six (6) test dives to evaluate the floatation characteristics of a diver in a completely flooded drysuit without a buoyancy compensator device (BCD) and weight belt. The test divers were NOAA-certified working and scientific divers and ranged in age, size and diving experience level. The test procedures involved descending to the bottom of the 30-foot deep tank located at NDC. Once on the bottom, the test divers flooded their drysuit via the neck seal or zipper with the assistance of the safety divers. With flooded suits, the divers attempted to swim to the surface still wearing their weight belts. If the diver could swim to the surface, they were instructed to drop back to the bottom, drop their weight belts and make another ascent to the surface. At the surface the divers were required to remain afloat without assistance for 30 minutes. Following the dives, each test diver filled out a questionnaire (attached) concerning the dive. All six (6) test divers indicated that they could remain afloat without a BCD and weight belt in the unlikely event of a flooded drysuit. Three (3) of the divers indicated that, depending on the type of drysuit worn, a BCD would be an added layer of safety, especially in a flooded situation. However, none of these individuals felt that a BCD should be mandatory when wearing a drysuit.

BACKGROUND

The NOAA Diving Program (NDP) currently does not require NOAA divers to wear a BCD when diving with a drysuit. The rationale for such a position has been that there is sufficient inherent buoyancy, even in a totally flooded suit, to keep divers afloat on the surface in an emergency. Should a drysuit become flooded, due to the loss of a seal, a malfunctioning exhaust valve, or a tear in the suit, NOAA divers are trained to ditch their weight belts and ascend to the surface. Once on the surface, topside support personnel are there to assist the divers exiting the water.

In the late 70s, NDP conducted a series of test dives to determine if a diver could swim a totally flooded drysuit to the surface and stay afloat without the assistance of a BCD. The dive platform used to conduct these dives was a 110-foot deep, freshwater tank located in White Oak, MD. Two types of drysuits were tested: a vulcanized rubber (Viking®) and a ¼" thick neoprene (Unisuit®). Once on the bottom of the tank, divers unzipped their suits, ditched their weight belts, and ascended to the surface. Safety divers were used to assist the diver if trouble were to arise. The results indicated that divers could swim flooded drysuits to the surface and remain afloat with only minor fin kicking without the aide of a BCD.

Now in 2002, the NDP intends to duplicate, expand on, and record these efforts. Using volunteer NOAA divers, NDP will test the drysuits currently issued through the SEP program. The suits to be tested include the ¼" thick neoprene Unisuit®, 4mm thick compressed foam neoprene Abyss®; 2mm compressed foam neoprene Abyss®, Viking® vulcanized rubber and the Gates tri-laminate suit. The test dives will take place at the NDC using the 30' freshwater deep tank as the dive platform.

PERSONNEL

The test dives were conducted using the following personnel:

- Dive supervisor: Responsible for planning and supervising dives, assigning positions, and writing report at conclusion of test
- Topside tenders: Responsible for assisting divers with dressing and undressing and water entries and exits
- Test divers: Responsible for performing dives and completing written evaluations after their dives
- Safety/photographer divers: Responsible for providing routine and emergency support for test divers. If the situation allowed, the Safety/photographer divers also documented the test using a digital still camera
- UW video divers: Responsible for shooting both topside and underwater video footage of the test

Divers were selected by age, size and dive experience level.

- The diver's ages ranged from 25 yrs – 48 yrs.
- The diver's height and weight ranged from 5'4" 115 lbs – 6'8" 230 lbs.
- All divers were NOAA employees and were certified as NOAA Working or Scientific Divers
- The diver's previous experience level ranged from 30 – 330 previous dives.

TEST PROCEDURES

Six (6) dives were completed - each taking approximately 45 minutes.

The dives were conducted as follows:

- Test divers, accompanied by a safety and underwater video diver, entered the water and descended to the bottom of the 30 foot deep tank located at NDC.
- Once on the bottom, test divers flooded their drysuits via their neck seals or zippers with the assistance of the safety diver.
- When flooded, the divers attempted to swim to the surface without removing their weight belts.
- If the divers were successful in swimming to the surface, they were instructed to descend back to the bottom, drop their weight belts and make another ascent. If too buoyant, the divers controlled their ascents by assuming a flared position and pulling themselves down with their hands against the water.
- At the surface, the divers were required to stay afloat without assistance for 30 minutes.

Following the dives, all divers completed the following questionnaire:

- Do you currently use a BCD when diving with a drysuit? Yes___ No___
- Give your opinion of the dive.
- Do you think the test dives were legitimate? Yes___ No___ Why?

- Have these dives changed your opinion on the use of a BCD with a drysuit? Yes___ No___ Why?
- Bottom line, do you feel you could safely stay afloat for: 30 minutes in a flooded drysuit without a BCD in the conditions you currently or anticipate diving in?

OBSERVATIONS

Open-Cell Neoprene (Unisuit®)

- Supervisor observations
  - Ascent to the surface and a thirty-minute float with a flooded suit posed no problems for the divers.
- Recommendations
  - Instead of dropping weight belts at bottom keep the belt on until at the surface and then drop if necessary.
  - If belt is ditched on bottom, the divers should assume a flared position to control ascent.

Compressed-Cell Neoprene (Abyss® 2mm and 4mm)

- Supervisor observations
  - One diver seemed to have difficulty kicking the suit to the surface with a weight belt – possibly due, in part, to the small stature of the diver. The divers were able to drop their weight belts on the bottom and still do a controlled ascent to the surface.
  - All divers were able to stay afloat on the surface without much physical exertion.
- Recommendations
  - The decision to drop the weight belt at the bottom prior to ascent will have to be made by the diver based upon their ability to swim the suit to the surface.

Vulcanized Rubber (Viking®)

- The Viking suit required more physical effort to maintain buoyancy at the surface than either the open-cell or compressed neoprene suit (there is no inherent buoyancy in the vulcanized rubber suit.) The divers could not swim the suit to the surface with the weight belt on.
- Recommendations
  - Have divers drop weight belt on bottom before beginning ascent.
  - On surface, the divers may ditch their backpack and scuba cylinders if necessary to help maintain positive buoyancy.

Tri-laminate (Gates®)

- There was no inherent buoyancy in the tri-laminate suit, but the diver was able to maintain positive buoyancy on the surface with little effort. The diver seemed more comfortable at the surface than did the Viking diver even with a scuba cylinder that registered over 2,000 psi.
- Recommendations
  - Drop the weight belt on the bottom and make a controlled ascent to the surface.
  - On the surface, if assistance is not immediately available, then drop the backpack and scuba cylinders if necessary.

RESULTS OF QUESTIONNAIRES

DIVER # GENDER - AGE # DIVES	**Do you currently use a BCD when diving with a drysuit?**	**Give your opinion of the dive.**	**Do you think the test dives were legitimate?**	**Have these dives changed your opinion on the use of a BCD with a drysuit?**	**Do you feel you could safely stay afloat for 30 minutes in a flooded drysuit without a BCD in the conditions you currently or anticipate diving in?**
Diver #1 Male - 48 yrs 90 dives	No	"It was an effective demonstration of the Unisuits buoyancy while flooded"	Yes. "The suit was completely flooded but I was able to stay afloat for 30 min. with tank and ankle wts."	No. "The considerable buoyancy of the suit while flooded." "Ability of the upper suit (above zipper) to retain air."	Abyss 4mm - Yes
Diver #2 Female - 32 yrs 55 dives	No	"The dive went fine-instructions were good. It was interesting and informative to see what would happen in the event of a flooded suit. Very useful to try a regular ascent, then ascent while flared and kicking to ascend slowly, then swimming to the surface with a weight belt to which was more feasible."	Yes. "Very legitimate – important techniques for different suits (buoyant and non-buoyant suits). A good set of tests.	Yes. "This has at least made me consider using a BCD, but it would depend on the suit for me. In an Abyss or Unisuit without a BCD would be better (you could fight the ascent), but in a Viking I would want a BCD."	Abyss 4mm - Yes Viking - Yes Unisuit - Yes

DIVER # GENDER - AGE # DIVES	**Do you currently use a BCD when diving with a drysuit?**	**Give your opinion of the dive.**	**Do you think the test dives were legitimate?**	**Have these dives changed your opinion on the use of a BCD with a drysuit?**	**Do you feel you could safely stay afloat for 30 minutes in a flooded drysuit without a BCD in the conditions you currently or anticipate diving in?**
Diver #3 Male - 25 yrs 30 dives	No	"With my Viking suit flooded and all my weights ditched I was able to stay afloat for 30 min. I was negatively buoyant and had to tread water to stay afloat. It was work to stay afloat and I was beginning to tire after 30 min. Ditching my tank made me less negative and made it easier to stay afloat."	Yes. "I dove with all my gear as I would in the field. Most sites I dive would not have significant current or sea state so this tank was similar in that regard."	No. "In the rare event of a flooded suit I was still able to safely reach the surface and stay afloat for what should have been enough time for help to arrive."	Viking - Yes
Diver #4 Male - 37 yrs 30 dives	No	"Good experience on what happens if a drysuit completely floods. It also increased my awareness of the effects of cold water on the body. I will take the issue of proper clothing more seriously."	Yes. "Suit was completely flooded and the dive tank was a good place to do an controlled experiment."	Yes. "Depending on the type of drysuit worn I would consider wearing a BCD. It would not be unsafe to not wear a BCD, I feel confident about staying afloat and getting to shore/boat. It would just be an added layer of protection with a non-neoprene drysuit."	Viking - Yes Unisuit - Yes

DIVER # GENDER - AGE # DIVES	**Do you currently use a BCD when diving with a drysuit?**	**Give your opinion of the dive.**	**Do you think the test dives were legitimate?**	**Have these dives changed your opinion on the use of a BCD with a drysuit?**	**Do you feel you could safely stay afloat for 30 minutes in a flooded drysuit without a BCD in the conditions you currently or anticipate diving in?**
Diver #5 Male - 33 yrs 330 dives	No	"I used the 2mm Abyss. I was able to both swim the flooded suit to the surface with weights & control the ascent without weights. Preferred method would be to drop the weights & flare to control the ascent rate. I could have swam back to the bottom if necessary. Staying on the surface without weights was no problem. I still had ankle weights & my knife on. No kicking was required to stay afloat."	Yes. "The Unisuit test should have had Mike Lemon flare. But all of the rest of the test were a good simulation of the worst case scenario for a dry suit flood.	No. "Still should be an option if they do not cover valves or weight belt releases."	Abyss - Yes

DIVER # GENDER - AGE # DIVES	**Do you currently use a BCD when diving with a drysuit?**	**Give your opinion of the dive.**	**Do you think the test dives were legitimate?**	**Have these dives changed your opinion on the use of a BCD with a drysuit?**	**Do you feel you could safely stay afloat for 30 minutes in a flooded drysuit without a BCD in the conditions you currently or anticipate diving in?**
Diver #6 Male - 39 yrs 125 dives	No	"I think it is great that NOAA is testing diving equipment and exploring diving techniques. This is a needed diving experiment and overdue. More rigorous conditions might be tested in the future."	"Yes the test was legitimate but limited to the specific drysuit and more specific the controlled conditions. Given Alaska conditions remaining at the surface for a minimum of 30 minutes without a floatation device (BCD) may be a risky venture."	No. "I believe using a BCD is a wise safety device. Given the low cost and that most divers are familiar with them I think they should be recommended as part of the NOAA dive equipment."	Tri-laminate - No

RESULTS

1) All of the test divers indicated that they could stay afloat in the particular drysuit that they used for the test without a BCD, in a totally flooded condition.
2) Three (3) of the test divers felt that the use of a BCD would add a layer of safety for a flooded drysuit, but that a BCD should be optional.

CONCLUSIONS

The inherent buoyancy exhibited by the neoprene drysuits, enabled the divers to swim the suits to the surface and remain afloat with very little effort and without the aide of a BCD even in a flooded condition. Although the vulcanized rubber and tri-laminate suits displayed no inherent buoyancy, the test divers were still able to swim to the surface and remaining afloat despite being flooded. However, because of the physical exertion required to maintain positive buoyancy when flooded, a BCD may be advantageous when wearing a vulcanized rubber or tri-laminate suit.

It is recommended that weight belts not be ditched prior to reaching the surface unless divers cannot physically swim to the surface. This will help prevent divers from making an uncontrolled ascent. Once on the surface, removal of weight belts will increase divers buoyancy and reduce effort required to stay afloat.

Based on these tests, it is recommended that the NOAA Diving Program: 1) disseminate the findings of this report to all NOAA divers, and 2) leave the use of BCDs with drysuits optional for NOAA divers.