

Testing inside of a Pressurized Submarine Decompression Chamber

Contract & Manufacturing History

In October of 1998, ETC was awarded a Contract by the United States Navy (NAVFACCO), Washington Navy Yard, for the manufacturing, testing and integration into the Navy's submarine rescue program, for two Submarine Decompression Systems (SDS).

The SDS's are an element of the Submarine Rescue Diving Recompression System (SRDRS), which is the US Navy's next generation submarine personnel rescue system. The SRDRS is a rapid assessment, global response system designed for the rescue, and transfer under pressure of personnel from a disabled submarine (DISSUB).

The complete USN Submarine Rescue Diving Recompression System (SRDRS) comprises three major sub systems:

- Submarine Decompression System (SDS)
- Submarine Hyperbaric Occupant Transfer System (SHOTS)
- Rapid Assessment and Underwater Work Systems (AUWS)

The heart of each SDS is a decompression chamber that is capable of accommodating up to 33 persons; 31 rescued submariners, and 2 inside tenders. The hatches, access ways and interior layout of the Chambers are designed to accommodate 95th percentile submariners.



View of SDS

(Note the two large entrance hatches)

Each SDS, and its associated Mission Support Equipment, is intended to respond to worldwide emergency DISSUB alerts. To complete their worldwide mission, they are designed to be easily transportable by Road, Air, and Sea. The SDS has an approximate length overall of: 9.8 m (33.5ft) and an outer diameter of: 2.0 m (6.5 ft) and has a maximum operating pressure of 6 atmospheres absolute (ATA).

These pressurized SDS chambers are mounted inside a custom designed and built Van. Each chamber also has it's own control room, which is internally located at one end of the SDS Van.



SDS Control Room
(Note the Transfer Lock below the viewport)

The SDS Van is based on the standard dimensions of an ISO container, and designed to sustain transportation loads and wave slap loads when mounted on a Vessel Of Opportunity (VOO) such as the standard US Navy Fleet Ocean going Tug (T-ATF)



VOO US Navy Ocean going Tug

ETC's history of PVHO vessels.

ETC has a long and distinguished history of designing and manufacturing large Hyperbaric chambers. Notable vessels manufactured by ETC include the Hyperbaric chambers at David Grant Medical Center at Travis AFB, which are the largest in the United States, and the large chamber located at Carraway Methodist Medical Center in Birmingham Alabama. Smaller hyperbaric chambers include ETC's BARA-MED[®] Monoplace Hyperbaric Chamber, which is a cylindrical Acrylic window design with automatic dive profiles.

Technical Achievements of this Contract & these vessels:

Because of contractually specified performance requirements, and especially the size and weight restrictions, these chambers could not be designed using standard "ASME or PVHO-1 out of the book" methods. ETC utilized ANSYS Finite Element Program backed up other analyses and modeling programs. These chambers are probably the largest and lightest transportable pressure vessels for human occupancy ever built in full compliance with ASME-PVHO-1 Code.

Testing inside the SDC

The SDS and it's associated mission support components, are currently undergoing certification by NAVSEA - OOC in accordance with SS521-AA-MAN-010, US Navy Diving and Hyperbaric Systems Safety Certification Manual (referred to as MAN-010).

As part of Naval Acceptance test protocol for these chambers, it is required that certain tests and adjustments be conducted inside the chamber while under pressure. This required two ETC personnel, qualified in dive operations, to "descend" to the SDS Maximum Working Pressure of 165 feet in depth, and perform adjustments to the Built In Breathing System (BIBS) air flow regulators.

We also had to perform tests to verify performance of the internal manifold supply lines.

Prior to the start of the Dive, the entire dive was reviewed and briefed to all personnel by the Chief Physiological Officer, and the Dive Safety Officer, who planned the dive, using the US Navy "Dive Tables" for dive and decompression times. The chamber was "preflighted", the dive was reviewed, loss of communication signals was rehearsed, safety checks performed, and a medical review of the divers performed.

Life under pressure in an SDS Chamber is, well, interesting. While having first hand knowledge of diving and the effects of pressure in an aquatic environment, it was this author's first experience at this pressure, and the associated effects of nitrogen narcosis. Prior to the dive, I felt comfortable knowing that my "Top Side" supervisory dive team was very experienced, and they would actually monitor my health and well being. Also in the chamber with me, would be my very experienced "dive buddy" who had previously worked as a commercial diver. I would come to rely on his experience of being able to work in a pressurized environment while under the intoxicating effects of nitrogen narcosis.



Glenn King

Dive Buddy, Larry

For those unfamiliar with diving, the effect called **NITROGEN NARCOSIS** commonly referred to as "rapture of the deep," occurs while breathing air, beginning at depths approaching 100 feet, and this effect can become incapacitating at depths of 300 ft. Our test dives required us to be compressed to a depth of 165 feet, with bottom times approaching 60 minutes.

The air we breathe is composed of approximately 80 percent nitrogen and 20 percent oxygen. Without getting into the details of Dalton's Law of partial pressures, during every dive, the increased pressure causes the nitrogen to dissolve into the blood and body tissues. At elevated pressure levels, nitrogen has an anesthetic effect. This effect impairs the conduction of nerve impulses and

mimics the effects that alcohol or narcotics would have on the brain. The amount of nitrogen the body absorbs on a given dive depends on how deep and how long the dive is, but the deeper the dive and the longer the stay, the more nitrogen the body absorbs. This is commonly known as the “martini effect.” Basically, every 33 feet in depth has an effect that is roughly equivalent to one martini. Therefore, I was happily experiencing the effects of five martinis in my dive.

A common symptom of the effects of nitrogen narcosis, and of those I experienced, was behaving as if I was intoxicated, with my coordination and judgment impaired. Additionally divers may experience a feeling of false security and exhibit a lack of concern for safety.

More often it is not the direct effects of nitrogen narcosis that kills, but the resulting impaired judgment, poor decisions, and loss of coordination that causes fatalities.

Our dive to depth was fortunately uneventful, thanks to the watchful eyes of our Topside Team. The hissing of the incoming air, the heat of the compression, and the constant Valsalva maneuvers, kept our ears adjusted to the increasing depth. An interesting side effect of the increasing pressure was the difficulty everyone had in discerning if my voice, which sounded like “Mickey Mouse”, was an effect of the increased pressure on my vocal cords, or just my personality coming out as a result of the nitrogen narcosis.

The good news is that our tests were completed without incident, and the integrity of the vessel was sound. No leaks, creaks or abnormal indications were found during our testing. All the valves were adjusted, checked, and set. Each test passed to the satisfaction of the Navy, who witnessed and monitored our tests and activities.

Now, with testing finished, the most critical part of the dive was about to commence, the decompression. As we slowly decompressed, the effects of nitrogen narcosis began to fade. However, another potential serious medical condition had to be avoided; Decompression Sickness (DCS), or more commonly called “the bends”.

We planned the dive using the US Navy Dive tables. When used by properly trained personnel, these tables provide a safe series of decompression stops or “hold points” during our ascent to allow us to safely “off-gas” the nitrogen our body had absorbed

As you ascend, the surrounding pressure decreases, and the nitrogen which has been absorbed into our blood and tissues, begins to leave the body. The excess nitrogen is normally eliminated through respiration, because unlike oxygen, the body does not use nitrogen. As long as the amount of excess nitrogen is kept to within reasonable limits, the body can eliminate it without complication during a slow decompression.

However, if the decompression is too rapid, as when a diver runs out of air and races to the surface, decompression sickness may occur as the dissolved nitrogen begins to form bubbles within the body. This is a serious condition, both painful and potentially life threatening. We were very careful to avoid this condition by following a slow, safe ascent rate with decompression stops at proper time and depth intervals established by the dive tables. Additionally, to increase the safety margin of our dive, we followed a very conservative dive and decompression plan and we breathed oxygen at decompression stops. We also did not perform multiple dives or fly in an airplane within a 24 hour period.

I'm happy to report that our testing was a complete success, and that neither Larry nor I have any residual symptoms of our dives. However, something more important than just the completion of these tests evolved from these dives. Lives depend upon the quality and integrity of these vessels, which must work perfectly every time they are put into service. I for one believe the Navy has a higher level of confidence in both ETC and their new SDS Chambers knowing that ETC's Director of Quality Assurance, was willing to actively participate in these tests from within the pressurized vessel. However, like all great accomplishments of this magnitude, it was a team effort. Both Larry and I greatly appreciate the excellent monitoring and dive control provided by our Topside Team.

Glenn King is the Director of Quality Assurance for ETC.