US NAVY DIVING PROGRAM:
DIVING TO 300 FT DEPTHS USING
SURFACE-SUPPLIED AND SATURATION FLY-AWAY DIVING SYSTEMS

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Introduction

Diving to 300-foot ocean depths began early in the last century exclusively through use of surface-supplied diving equipment. With the advent of self-contained apparatus in the 1940s, technological advances safely permitted short duration diving to depths approaching and even exceeding 300 feet. Nonetheless, for bottom times greater than 15 minutes, surface-supplied diving continues to retain a number of advantages over current self-contained rebreather technology. For really long bottom times, measured in hours instead of minutes, saturation diving is the most efficient and efficacious method to accomplish work at ocean bottom depths.

This paper addresses the U.S. Navy’s mixed-gas surface-supplied and saturation diving equipment and capabilities. For many reasons beyond the scope of this paper, U.S. Navy diving systems greatly exceed what is required in many commercial diving operations, and almost all scientific diving operations. Frequently, U.S. Navy diving systems are designed to substantially different requirements than standard commercial diving equipment and, therefore, are much more costly, sometimes by an order of magnitude than commercial counterparts.

Surface-Supplied Diving

Although equipment and procedures exist in the U.S. Navy diving program to reach depths as deep as 300 feet of sea water (fsw) using closed-circuit rebreathers (in particular the USN Mark 16 Mod 1 using a 1.3 ata constant partial pressure of oxygen), almost all deep working dives employ mixed-gas surface-supplied diving systems instead. The rationale behind preferred use of surface-supplied systems is straightforward:

1. increased safety associated with direct umbilical connection to the diver;
2. improved communications between topside and the diver;
3. greatly improved thermal protection through use of umbilical-supplied hot-water suits; and,
4. ability to employ surface-decompression on oxygen (sur-D-O₂) techniques, which greatly reduce the diver’s in-water decompression obligations.

Figures 1 and 2 document the substantial in-water decompression differences between 300 fsw dives for similar bottom times of the U.S. Navy Mark 16 Mod 1 decompression tables and the U.S. Navy Helium-Oxygen sur-D-O₂ decompression tables. Additional advantages to the use of surface-supplied systems for deep ocean working dives include safer means to achieve significant internal wreck penetration, use of video cameras, and communications tethered to the diver. These allow many more “topside experts” to engage with and direct the diver on task, and a greatly improved “turn-around” of dive team rotation by use of sur-D-O₂ (next dive team can deploy as soon as first dive team is safely locked down in the recompression chamber undergoing decompression on oxygen).

Figure 1. In-Water Decompression Obligations (Surface Supplied vs. MK 16 Rebreather).
Figure 2. Total Decompression Obligations (Surface Supplied vs. MK 16 Rebreather).

Surface-supplied diving does have disadvantages over closed-circuit deep diving. Many working scientists may prefer the improved diver mobility resulting from elimination of the topside umbilical connection. Further, several closed-circuit rebreathers, though by no means inexpensive, generally can be purchased and supported for much less than a full mixed-gas surface-supplied system, certainly much cheaper than the U.S. Navy “Fly-Away Mixed Gas Diving Life Support System” a.k.a. FADS III. The manning of a surface-supplied diving team generally is 2 to 3 times larger than that required for a closed-circuit rebreather team.

Fly-Away Mixed Gas Diving Life Support System

In recent years, the U.S. Navy Diving Program developed a modular system of diving components that can be assembled to provide either air (capable of diving to 190 fsw) or mixed-gas surface-supplied diving (capable of diving to 300 fsw). Since this workshop is intended to address diving to depths of 300 fsw, the mixed-gas capability is described below. The FADS III was designed to support gas capacities for 2 divers simultaneously diving to depths of 300 feet with maximum bottom times of 30 minutes, and decompressing on helium-oxygen surface decompression on oxygen (HeO₂ sur-D-O₂) tables. Additionally, sufficient gas is provided to support a third “stand-by” diver to 300 feet for 30 minutes in the unusual circumstance that one or both of the primary divers gets fouled on the bottom and needs assistance clearing himself. This is not a small system; it requires approximately 325 square feet of deck area, and weighs in at 38,000 lbs. The good news is that it can be easily transported in component parts, and is “ruggedized” to withstand any mode of transportation, from standard over-the-highway trucking, to rather high-impact vertical landing on decks when transported as suspended external loads under helicopters.

Figure 3 provides a cartoon schematic of the principal FADS III components. The primary breathing gas system is the Helium-Oxygen Supply Rack Assembly (inevitably called the HOSRA) composed of nine composite high-pressure (5000 psi) storage flasks (each of three cu ft floodable volume) contained in a rigid open cube structure for transport and storage. Typically, two HOSRA are used to configure the FADS III. The HOSRAs are recharged as necessary with a 5000 psi heliox boost pump assembly. Oxygen for decompression and treatment gas is supplied through an OSRA or Oxygen Supply Rack Assembly, fundamentally similar to the HOSRA, but charged to 3000 psi. Accompanying the OSRA is an oxygen boost-pump assembly for OSRA recharging. Of course, we need an ASRA (Air Supply Rack Assembly) for recompression chamber operations, and in an extreme emergency, in-water air decompression tables. The ASRA is backed up by a 5000 psi air compressor assembly. All of these gases are regulated to the divers through the mixed-gas control console assembly (which strangely has no particular acronym, it’s just called the “console”). Any number of recompression chamber configurations can be used with the FADS III, but generally, the U.S. Navy
deploys one of our containerized “Standard Navy Double-Lock” or SNDL chambers to round-out the FADS III system.

Typically, at least 13 dive team members are required for each shift of deep surface-supplied mixed-gas diving. If several weeks of continuous 24 hours per day operations are desired,

Figure 3. U.S. Navy Helium-Oxygen Fly Away Mixed-Gas Diving Life-Support System (aka FADS III) With Recompression Chamber.

our experience indicates approximately 24 personnel are required per 12-hour shift (or 48 personnel per day). On each shift, the minimum U. S. Navy personnel requirements include:

- 1 Diving Officer
- 1 Master Diver / Diving Supervisor
- 1 Medical Diving Technician or Diving Medical Officer
- 3 Divers (1 is a Stand-by Diver)
- 5 Diver-tenders
Saturation Diving

If long-duration operations to depths approaching or exceeding 300 feet are required, a much preferred approach, and in the long-run often a much less expensive (including manpower), is to use saturation diving. The benefits of saturation diving are by and large obvious, with the principal benefit being essentially unlimited bottom time. A direct advantage of saturation diving over surface-supplied diving for long-duration operations is that of individual diver learning-curve. For many surface-supplied operations, the actual effective bottom time is substantially less than the total bottom time. Travel times, deployment from the stage to the work-site, and recovery of the diver from the work-site to the stage prior to leaving the bottom all directly detract from productive work on the site. Even worse, changing out divers so frequently almost invariably leads to working the proverbial two-steps forwards and one-step back every time a new shift of divers deploys. Saturation divers, on the other hand, have a much smaller personnel rotation, so their familiarity and job-specific expertise builds instead of retreats on each job, in many cases accelerating work production with each subsequent dive rotation.

Saturation Versus Surface-Supplied Diving

Each of these benefits was quantifiably measured during U.S.S. MONITOR recovery efforts in 240 fsw off Cape Hatteras (the Graveyard of the Atlantic) during the summers of 2001 and 2002. U.S. Navy divers worked side-by-side with both types of systems, deploying from a 2-man saturation bell while at the same time conducting surface-supplied mixed-gas operations. Undeniably, the success of the operations during both summers was strictly due to the extraordinary work capacity of the saturation diving team. Had the saturation system not been used, MONITOR’s engine and turret would still lie in ruins on the ocean floor continuing to corrode instead of now curated in their preservation tanks ashore. A graphical comparison of the operational window of saturation diving, as well as a side-by-side quantification of saturation diving work efficacy and efficiency as compared to surface-supplied heliox diving are presented in Figure 4.
Conclusion

As the U.S. Navy embarks on procurement of a highly-portable Saturation Fly Away Dive System (SAT FADS), we are interested in finding joint operational missions with NOAA and the science community to allow us to operationally deploy, train, and maintain proficiency of our saturation diving community, but also to productively engage in further development of scientific research. When deployed in 2007, the SAT FADS will access 100% of the world’s continental shelf, permitting scientific exploration of a largely unknown frontier. SAT FADS operations will prove efficient from both a cost and work accomplished standpoint in depths as shallow as 150 feet of water (air saturation) to 700 feet and greater (heliox saturation). Anyone with potential scientific missions willing to cost share operations of this nature are invited to contact the Office of the U.S. Navy Supervisor of Salvage and Diving (202.781.0731), or email us through our website at www.supsalv.org.