Blueprint For Survival 2.0 – TECHNICAL DIVING

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Though technical training standards have been well established by the American Nitrox Divers, Inc. (ANDI), International Association of Nitrox & Technical Divers (IANTD), Professional Scuba Association (PSA), and Technical Diving International (TDI)&endash;and are continuing to evolve&endash;there is currently no set of agreed upon operational guidelines, i.e. guidelines used to direct diving operations, similar to those developed by the professional and commercial diving communities.

Originally published in aquaCORPS Journal N6/Computing (93JUN), the guidelines listed below were compiled by Capt. Billy Deans/Key West Diver and Michael Menduno/aquaCORPS with the help of many individuals throughout the community in response to the number of technical-level accidents that were occurring during that period. They were based on what we perceived as the "best practices" from the technical diving community drawing heavily on accident analysis techniques developed by the cave diving community, and were offered as a starting point for the development of "community consensus" guidelines for technical divers.

Now two years later, in light of the tremendous growth in technical diving, and with the majority of the recreational training agencies beginning enriched air nitrox we felt it was necessary to update and republish these guidelines. To do that we have contacted leaders from around the community including the heads of the technical training companies asking for their comments and feedback. These are shown below. As such this document represents a community perspective which we are pleased to offer to our readership.

Background

About twelve to fifteen years ago in response to the then growing number of fatalities, the cave diving community developed a set of safety principles based on the then-new tool of "accident analysis." Later refined by pioneer Sheck Exley and elucidated in his book Basic Cave Diving: A Blueprint for Survival (Exley, 1979, 1986), accident analysis is a means to rigorously dissect an accident into its constituent parts with the goal of determining "what went wrong." Applying this tool to cave diving, it was discovered that most diving accidents could usually be attributed to a primary causal factor and typically one or more contributing factors. What's more is that these factors could be boiled down into five basic cave diving safety principles: be trained, use a continuous guideline to the surface, manage your gas according to a thirds rule or better, don't dive deep (on air), and carry at least three lights. A sixth principle, known as "Eternal Vigilance," states: "Anyone Can Die At Any Time On Any Cave Dive." Accident analysis of these resulting safety procedures have become the cornerstone of cave diving safety ever since.

Numerous other analyses of sport diving accidents have been conducted following the early cave diving work. In 1989, Mano and Shibayama published a study titled "Aspects of Recent Scuba Diving Accidents" (Mano and Shibayama, 1989), which analyzed 264 fatalities and 319 incidents of compression illness and arterial gas embolism. According to the authors, over 45% of sport diving fatalities that occurred were due to "reckless diving" or "lack of technique." Most appear to have been preventable. In another study, Chowdhury, in affiliation with the National Underwater Data Center (Chowdhury, 1989) conducted an analysis of wreck diving accidents. His conclusions were that 73% of the accidents involving wreck penetration were due to the "lack of a continuous guideline," while 42% of the fatalities that occurred external to a wreck were due to "out of gas" emergencies.

In 1990, Exley revisited his earlier work in a paper published in Underwater Speleology. Based on the recent trends in accidents, Exley concluded that perhaps too much emphasis was being placed on the basic cave diving principles in light of more recent tools and techniques being employed by cave divers (e.g., mix technology), and that an expanded list of safety recommendations should be developed.

Exley's conclusions provided motivation for the original paper. Our approach was to attempt to identify and address the factors that could potentially result in diver injury or death, building on the cave diving safety principles and practices from the community. The resulting guidelines are organized into seven categories: Requirements, Training, Gas Supply, Gas Mix,

Decompression, Equipment, and Operations.

Requirements

The generalized requirements for conducting technical dives were aptly summarized in the form of the acronym AKTEE. These are:

Attitude: Why are you doing this? A proper attitude is essential to conducting technical dives safely. There is no room for recklessness or machismo.

Knowledge: Without the proper knowledge, there are no options when problems occur.

Training: Skills must become second nature&endash;a part of muscle memory.

Experience: Experience is exposure and environmental specific and takes time to build. Extensive wreck diving experience does not qualify a diver for cave diving and visa versa.

Equipment: Every dive requires an appropriate set of tools.

Note that the more challenging the dive and the further the dive goes beyond mainstream sport diving limits, the more risk the diver must accept. No amount of training or equipment will completely mitigate this risk.

Training

Technical training is an ongoing process similar to training for an athletic season or fight training. Continual practice is the key. Completing a formal course is a good first step, but is only a starting point. It does not in itself prepare you to make the dive. Technical diving is a discipline, not a card.

1. Always be prepared and trained for the dive you plan to conduct. Perform a risk assessment. Ask yourself if you, and your partner, meet the AKTEE criteria and if the dive is worth the risks involved. If the answer is no to either question, call the dive.

2. Review and practice emergency procedures frequently so that they become second nature.
   Gas Supply

Ensuring adequate gas supply is the major constraint factor in self-contained diving and represents the single largest risk factor. In particular, planning and carrying adequate gas reserves is critical.

3. Always dive an appropriately redundant breathing system (minimally first and second stage redundancy) in an overhead environment, or when diving in open water beyond 130 f/ 40 m. Second stage redundancy and a dive partner is an acceptable redundant system in open water no-stop diving (recreational diving) to 130 f/40 m in good conditions though an independent redundant system is recommended for dives deeper than 60 f/18 m and/or in less than ideal conditions.
4. Pre-plan and calculate the gas required to conduct the dive (Gas requirements = planned consumption plus required reserves) and dive your plan. Gas calculations should be based on the most conservative breathing rates of you and your partner. Always dive your bottom gas using at least the Rule of Thirds [Turn the dive when one third of your gas is exhausted, leaving two thirds for the exit and reserve] in an overhead environment, or a suitable equivalent in open water, depending on the operation. There should be sufficient reserves for the dive team to exist safely in the event one diver suffers a "catastrophic" gas loss. For extended open water dives, the consensus seems to be to reach your first decompression stop with one third of your bottom gas remaining.

5. Plan at least a 33% reserve (1.5 x planned usage) for your decompression gas. Depending on the operation, decompression cylinders should be equipped with redundant regulators.

6. When possible, carry all the gas you will need for the dive unless it can be reliably staged, depending on the operation and environment. Note that the ability to reliably stage gas is one of the major differences between cave and wreck diving. In open water diving the goal is to be "self-sufficient," to the maximum extent possible. Based on an analysis of gas logistics, the self-sufficiency "breakeven point" for extended open water dives appears to be about 250-300 f/77-92 m for a two-person team, depending on the duration of the dive. Open water dives beyond this require an extensive support team and effective communications.
Gas Mix

Mix technology is a tool designed to improve underwater safety and performance when properly applied. The most critical factor in special mix diving is oxygen management due to the risk of a CNS toxicity convulsion.

7. Always dive the safest possible mix(es) for the dive you plan to conduct.

8. Always analyze and label your gas and regulators before making the dive. Make sure that you know what you are breathing. Use a contents tag that specifies the type of gas and maximum operating depth. Any cylinder or regulator carrying a potentially hyperoxic gas (PO2=1.6+ at any depth during the dive) should also ideally have "touch ID" capability for zero visibility conditions (see below).

9. Maintain your PO2s at or below 1.45 atm during the working phase of the dive and anytime more than light work is being done, boosting oxygen levels to a maximum of 1.6 atm with care, during resting decompression. The community standard today is to run travel and bottom mix at about 1.2-1.45 atm, depending on conditions and the operation and PO2s of 1.4 -1.6 atm are generally treated as a caution zone. Take regular "air breaks, as a safety hedge every 20-25 minutes when breathing oxygen. " [If air is not available, the lowest FO2 travel gas should be used. Some trainers take breaks during the decompression phase of the dive whenever the CNS index exceeds 80%. Note that the CNS indices being used today are just guidelines and are not necessarily supported by hard data. As succinctly summarized by Terry Billingsley (Hamilton, 1985): "CNS toxicity is like sand beside the road. If you stay on the road, you won't get into trouble."]

10. "Just Say No" to nitrox mixes (like air) beyond about 180-200 f/55-61 m or less, depending on the operation and environment. In particular, keep equivalent narcotic depths (END) as

shallow as operationally and economically feasible, preferably 150 f/46 m or less. Note that ANDI limit s nitrox (air and EAN) exposures to 165 f/ 50 m. PSA allow s very short "non-working" exposures to 240 f/ 72 m and deeper under the supervision of two instructors per student.

Decompression

Decompression illness is not an accident. It happens and will continue to happen as a predictable part of diving.

11. Always use appropriate and reliable decompression methods and tools for the dive you're planning to conduct and be conservative. Carry bailout tables for gas loss scenarios.

12. Utilize a hyperoxic mix for decompression (e.g., oxygen and/or suitable EAN mixes) whenever possible when conducting a staged decompression exposure. Oxygen at 10 and 20 f/3 and 6 m stop is preferred in some circles [Air, and to a lesser extent EAN mixes, have been regarded as inefficient at reducing decompression risk (Vann, 1992)], though EAN 80 (80% O2, 20% N2) has grown in popularity as it is thought to reduce CNS toxicity risk and can be used at 30 f/ 9 m. Note just as it is recommended that divers make a "safety stop" on no-stop dives, some individuals prefer to treat the first (deepest) stop on a mix dive in the same manner and make a couple minute safety stop at least 10 f/3 m deeper than required.

13. Limit oxygen decompression to 20 f/6 m or less (max. PO2=1.6 atm) and use care. The diver breathing a decompression mix or oxygen should avoid anything that would increase the likelihood of CNS oxygen toxicity, or specifically, anything that might raise the diver's C02 level. Use an oxygen regulator "guard" to prevent the accidental use of pure oxygen at depth. Color coding and labeling are insufficient safeguards.

14. Plan for and always be prepared to deal with decompression illness (DCI). In particular, have plenty of oxygen immediately available for treatment after any diving operation and know how to use it. Many people believe that low-cost portable on-site chambers will eventually become the order of the day.

Equipment

Your equipment is your life support system which allows you to survive in a physiologically hostile environment. Second only to breathing equipment in importance, safety lines and a decompression line system are critical to diver safety.

15. Always use the best possible equipment that is well-maintained and appropriate for the dive you plan to conduct and the environment. Redundancy on all essential subsystems is key. In particular, always carry appropriate emergency equipment and know how to use it, for example: three lights (overhead environment), a decompression reel and lift bags (open water), surface signaling device (open water) and a bail-out bottle when diving as a team of one.

16. Always use a continuous guideline when diving in an overhead environment, and/or a decompression line system when conducting extended and/or deep open water dives. Note that conducting multi-level extended range open water hangs without a safety line home can be problematic and difficult. They require skills and practice to perform without compromising effective decompression, particularly when using hyperoxic decompression mixes where depth control is critical.

Note that the original set of guidelines (1993) included the following point;

If possible, wear breathing equipment that allows you to survive an underwater convulsion/loss of consciousness, such as a full face mask system or retaining strap. The use of full face masks is growing and will likely become a standard for many technical diving applications due to their many advantages.

In practice this point has not stood up in the field. Technical divers have not embraced full face mask technology, nor have FFMs become a standard. This may change when rebreathers finally hit the market and/or when an effective mask is developed for technical diving applications. In the meantime practice the effective and conservative use of oxygen management in order to avoid a CNS hit.

Operations

Technical dives are operations: a project or venture involving planning, preparation, organizational structure, the use of proper equipment, teamwork, competent execution, and the capacity to respond to emergencies effectively and immediately. Diver safety is always the first priority. In terms of support requirements, technical dives fall somewhere in between recreational dives and commercial operations. Note that all dives are operations. In the case of traditional "recreational diving," the requirements are minimal.

17. Pre-plan all aspects of the dive you intend to conduct and dive your plan. Design your operation with the goal of being able to provide effective and immediate assistance to a diver in distress at any point in the dive. In particularly be prepared for the worst, and always have plenty of oxygen on hand and know how to use it. Above all, if you’re not prepared to do it right, don’t do it.

18. Always dive as a team, using surface support personnel, and when appropriate, in-water support divers, whenever possible. In particular, designate an operations manager, who is responsible for overseeing diver safety and record keeping. Note that the "buddy system" is not reliable enough for technical diving. A team approach based on individual self-sufficiency and competency is required, though an team of one is acceptable in some circumstances, depending on the operation and environment. Above all, always honor rule number one of team diving: anyone can "call" the dive at any time for any reason (anyone can die just as easily).

19. Utilize an effective communications system between the dive and support team whenever possible. In the future, wireless communications systems will likely become commonplace.
20. Stay within your "comfort zone" during all phases of the dive.

21. Remember: YOU, and YOU ALONE, are responsible for your own safety. Never permit overconfidence or peer pressure to allow you to rationalize compromising safety procedures. It could ruin your whole day.

Definition: Technical diving is a discipline that uses special methods and equipment to improve diver safety and performance enabling the user to conduct dives in environments and perform tasks beyond the scope of traditional recreational diving i.e. no-stop dives in an open-water environment to 130 f/40, Europe; limited decompression dives to 50 m/165 f. For additional information see "technical Diving 3.1."