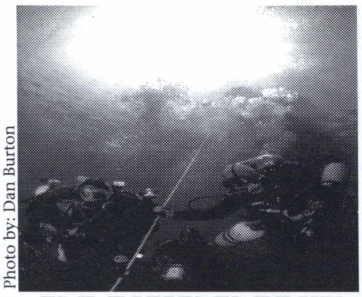

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SAFETY GUIDELINES FOR "EXTENDED RANGE" DIVES

by Michael Menduno and Capt. Billy Deans

Following the tragic "technical-level" accidents that occurred last summer in the U.S. (Menduno, 1992), the authors and other members of the community felt that a basic set of operational guidelines were needed to guide the conduct of "extended range" diving. Though initial training standards had been established by the American Nitrox Divers Inc (ANDI) and the International Association of Nitrox & Technical Divers Inc. (IANTD), and are continuing to evolve, there is currently no set of agreed to operational guidelines similar to those developed by the cave and scientific communities.*

This paper sets out a basic set of operational guidelines based on what we perceived as the "best" practices from the technical community drawing heavily on accident analysis techniques developed by the cave community. As such they represent a starting point for the development of "community consensus" guidelines for technical diving. We offer the following for consideration.

***Extended range** diving refers to self-contained sport diving beyond the established recreational/sport diving limits; (US) no-stop air dives in an open-water environment to 130 fsw, (UK) limited air decompression dives to 50 msw.

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 it's constituent parts with the goal of determining "what went wrong." Applying this tool to cave diving it was found 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, utilize a continuous guideline to the surface, manage your gas according to a third's rule or better, don't dive deep (on air) , and carry at least three lights. A sixth principle, known as "Eternal Vigilance," states that, "Anyone Can Die At Any Time On Any Cave Dive." Accident analysis and these resulting safety principles 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 decompression 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* (Exley, 1990). 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 (ex. mix technology), and that an expanded list of safety recommendations should be developed.

Exley's conclusions provided motivation for this 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 by technical operator, Jim Baden. These are:

- **A—Attitude:** Why are you doing this? A proper attitude is essential to conducting technical dives safely. There is no room for recklessness or machismo.
- **K—Knowledge:** Without the proper knowledge there are no options when problems occur.
- **T—Training:** Skills must become second nature— a part of *muscle memory.*
- **E—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.
- **E—Equipment:** Every dive requires an appropriate set of tools.

TRAINING

Technical training is an "ongoing" process similar to training for an athletic season or flight 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.*** Ask yourself if you, and your partner, meet the **AKTEE** criteria.
2. Review and practice ***emergency procedures*** frequently so that they become second nature.

GAS SUPPLY

Ensuring adequate gas supplies 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 about 60 fsw (18 msw).
4. ***Pre-plan and calculate the gas required to conduct the dive*** (Gas requirements = planned consumption plus required reserves) and dive your plan. Always dive your bottom gas using ***at least the Rule of Thirds*** 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 exit 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 fsw (77-92 msw) 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 you know what you are breathing.
9. **Maintain your PO2s *below 1.5 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. Take regular ***"air breaks"*** as a safety hedge every 20-25 minutes when breathing oxygen. 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 ("air") beyond about 180-200 fsw (55-61 msw)*** or less, depending on the operation and environment. *In particular keep equivalent narcotic depths (END) as shallow as operationally and economically feasible, preferably 150 fsw (46 msw) or less.*

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 your planning to conduct and be ***conservative.***
12. Utilize a ***hyperoxic mix for decompression*** (ex. oxygen and/or suitable EAN mixes) whenever possible when conducting a staged decompression exposure. Note that the technical community has become much more vigilant in the use of oxygen or EAN for decompression. Oxygen at 10 and 20 fsw (3 and 6 msw) is preferred. Air, and to a lesser extent EAN mixes, are generally regarded as inefficient at reducing decompression risk (Vann, 1992).
13. ***Limit oxygen decompression to 20 fsw (6 msw) 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 liklihood of CNS oxygen toxicity, or specifically, anything that might raise the diver's carbon dioxide 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 & 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 open water hangs without a safety line home is tricky and can be hazardous, particularly when using hyperoxic decompression mixes, where depth control is critical.

17. 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 the will likely become a standard for many technical diving applications due to their many advantages.

OPERATIONS

Technical dives are ***operations:*** *a project or venture involving; planning, preparation, organizational structure, the use of proper equipment, teamwork, competent execution, and the capability of responding 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 "recreational diving," the requirements are minimal.*

18. ***Pre-plan all aspects of the dive you intend to conduct.*** 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 particular, ***be prepared for the worst,*** and always have ***plenty of oxygen*** on hand and know how to use it. Above all, if your not prepared to do it right, don't do it.
19. ***Always dive as a team,*** utilizing ***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 extended range diving. A ***team approach*** is required though a *team of one* is perfectly acceptable in many 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.)
20. Utilize an effective ***communications system*** between the dive and support team whenever possible. *In the future, wireless communications systems will become standard.*
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.*

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Sheck Exley was one of the key individuals responsible for developing and applying "accident analysis " to cave diving. His book, ***Basic Cave Diving: A Blue Print For Survival,*** 5th Ed., 1986 is "required" reading for all technical divers. You can obtain a copy from the Cave Diving Section of the National Speleological Society, Po Box 950, Branford, FL. 32008.

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