

Equipment Testing

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Equipment testing is an important part of dive accident and fatality analysis. Stakeholders in the community have different and occasionally conflicting needs when it comes to such testing. Current practices are poorly standardized, including when testing is conducted, who is responsible for testing and what tests should be performed. This paper briefly examines current practices and proposes suggestions for future direction. Key among these is the need for rapid testing to occur, overseen by impartial investigators. A law-enforcement model is advanced, with all equipment being treated as evidence as opposed to personal property. Challenges inherent with this proposal include training of first responders, timely analysis, education of law enforcement agencies, access to testing resources, development of sufficiently detailed and standardized procedures, and funding to conduct such testing. A sample equipment evaluation procedure form for open-circuit scuba equipment is provided as Appendix E. A second form for the testing of rebreathers is also provided.

Introduction

Many stakeholders have an interest in scuba fatality investigations. Law enforcement, medical examiners and coroners, training agencies, liability insurance companies, equipment manufacturers, dive professionals, equipment retail establishments, dive-travel providers, victims' families, research groups and others have an interest in determining the cause of any incident. Essentially, all groups want more information to prevent future accidents and make scuba diving a safer activity.

Life-support equipment is an integral part of scuba diving. Generally, dive equipment is robust and functions as designed. However, poor maintenance, design flaws, improper use or other factors may contribute to, or cause, an incident. Even when equipment issues are not contributory to an incident, it is important to rule them out so that the cause may be determined from other factors.

Currently, equipment investigations are conducted in a variety of manners. There is no consistent community or national standard for such testing: who does it, what is done, how it is done or even why it is done. This paper will briefly examine such questions and suggest possibilities for future standardization of the above. Key questions and challenges will also be addressed, which will require further community discussion and development.

Why?

Multiple reasons exist as to why an examination of the equipment involved in diving incidents is desirable. Each of the interested parties has their own set of needs,

which are often complimentary but not always congruent. Law-enforcement authorities and medical examiners are charged with determining the mode and manner of death and investigating any criminal culpability. Victims' families want to understand what happened and why, often so that other families do not have to suffer the same pain and grief. Training agencies want better instructional programs to prevent similar future occurrences. Manufacturers want to improve equipment design. Insurance companies want to limit financial exposure. Research groups, like universities and nongovernmental organizations such as DAN, want access to better data.

Law-enforcement agencies are tasked with investigating dive-related fatalities with several goals in mind. The first is to determine if any criminal culpability exists on the part of another party. That party might be a dive partner, wife, boyfriend, girlfriend, dive instructor, divemaster, dive shop, boat crew or another party entirely. The criminal culpability could range from premeditated homicide to gross negligence leading to a diver's death. If dive fatalities are automatically assumed to be accidents, then criminal conduct will never be expected.

The second goal of the investigation is to determine or assist in determining why, how and when the fatality occurred. This information is very important to family members who cannot understand how their loved one died doing what most families consider a safe outdoor sport. Many families are not satisfied with a medical examiner's finding of drowning. This leaves too many unanswered questions. Families want to know why and how their loved one died. In most cases, families have difficulty accepting that their loved one might have made a mistake or otherwise been at fault. Often they want to assign blame elsewhere — for example, with the equipment, instruction or dive or boat professionals. If a complete investigation is not done by a law-enforcement investigator, many families will have trouble coping with the unanswered questions. This can lead families to file lawsuits that might have been avoided if a complete investigation was conducted.

Training agencies develop instructional programs in which equipment use and handling are incorporated. Much of this body of knowledge has been developed over years of instructional practice and subsequent operational use. However, new equipment, modifications to current equipment and usage in a variety of environments may lead to unforeseen issues or problems. While every attempt is made to identify potential problems before instructional programs are approved, not every circumstance can be anticipated. A dive fatality may be the first indication that a problem exists. Thus, analysis of a dive fatality may lead to changes in instructional certification programs or training practices.

Likewise, information gleaned from post-incident equipment testing may be used by manufacturers to improve equipment design. Often unanticipated usage by customers results in scenarios that were not expected. This may result in substandard equipment performance or suggest equipment design modifications extending the range of use. In other cases, broad, extended use of new equipment in the field may unearth problems that do not manifest themselves during research, development and testing phases of new product introduction.

Insurance agents want to limit financial liability regarding any given incident. The issue here is that many of the insurance companies may have conflicting viewpoints. A company providing instructional liability protection may welcome a finding that equipment might have been at fault. Another firm providing product liability would prefer a finding that shows the diver caused the incident by practicing improper dive procedures. The firm insuring the regulator used by the decedent would rather

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that the design of the BC used (which they do not insure) be determined to be deficient.

Finally, many individuals and organizations conducting research into dive safety would benefit from better information regarding equipment testing. Such test results might have significant impact regarding the evaluation of incidents and examination of their underlying causes. The quality of results or findings might be significantly improved with accurate post-incident equipment evaluation.

As can be seen from the above, a multiplicity of viewpoints surrounds any dive incident. All would benefit from an equipment review, but not necessarily from the same type of review. Our premise is that the greater needs of the entire dive community would be better served if detailed, timely and unbiased equipment testing was conducted on all dive fatalities. Currently, this is not the norm.

Current Practices

A wide range of practices currently exists as to what happens to dive equipment after an incident. Each of these has various advantages and deficiencies. Broad areas of concern in post-incident equipment testing include who (1) directs testing (direction), (2) conducts testing, (3) funds testing and (4) when such testing occurs. Each of these will be discussed in the following section.

Direction is defined as establishing the scope of testing, selecting who will physically conduct the tests and determining when testing will be conducted. In general, equipment testing is directed by one of three broad groups: public agencies, plaintiff attorneys or defense attorneys. Public agencies may include law enforcement, medical examiners or coroners. Generally these personnel are less biased in their approach to directing testing because they have no vested interest in the outcome or results. However, public agencies are usually the least likely to institute equipment testing because their motivation to do so is narrowly defined, i.e., the need to rule out homicide or determine a cause of death. Since the cause of death is often taken for granted to be “drowning” due to a “misadventure,” frequently both homicide and medically driven investigations are simply not conducted. This leaves equipment testing to be pursued by other groups.

If not initiated by public agencies, equipment testing is generally directed by attorneys. The attorneys involved may be working for plaintiffs or for the defense, but obviously in either capacity they have an interest in furthering their clients’ objectives. Thus, testing may be incomplete, often restricted toward achieving or defining a particular result. As an example, plaintiff goals might be to demonstrate that a particular regulator has inherent design flaws, was improperly serviced or adjusted by a repair facility or failed from manufacturing defects. The same regulator testing might be directed by defense attorneys to show that the regulator worked fine in practice, that the victim had possession of the equipment for a significant time post-servicing and may have either advertently or inadvertently altered key mechanical adjustments, or just used the regulator in an improper manner. In either case, even though they probably are not directly conducting the testing, their respective needs and objectives establish the limits of the personnel conducting the tests, leading to incomplete or biased results. All other equipment used during the incident may be virtually ignored, as it falls outside the scope of the narrowly defined needs of the client. Unfortunately, the majority of equipment testing is directed by these parties.

Most of the time the individuals directing the testing are not the same persons who conduct the tests. Instead, another group is tasked with actually performing testing. Groups currently used include dive stores, repair facilities, manufacturers, U.S. Navy,

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law-enforcement personnel, universities, independent consultants or insurance investigators. One of the primary concerns with all of these groups is that there is no standardized training or qualifications for conducting scuba equipment testing specific to incident analysis. While any given category may be well suited for one aspect of such testing, such as a repair facility regulator expert being trained how to service and maintain regulators, that same individual may have no or only limited knowledge in identifying problems that might lead to an incident and properly documenting the same. Law-enforcement personnel have extensive training in investigative procedures but limited, if any, knowledge of scuba equipment. Unfortunately, scuba-equipment testing requires knowledge of procedures, analysis, specific testing protocols, broad multimanufacturer knowledge base, documentation skills and report writing.

Nor is there a standard for what tests should be conducted. Current practices may range from a visual examination of the equipment to full disassembly, possibly including open-water trials in an environment similar to that experienced by the decedent at the time of the incident. Some testing is purely qualitative, while other testing is quantitative. No generally accepted standards exist.

Another issue again deals with bias. The most knowledgeable person on any given piece of equipment is probably a manufacturer's employee. However, that same individual will generally have an overt or subconscious desire to protect their employer, especially if they were involved in the design and production of the equipment. Other common sources of bias include personal equipment preferences of the individuals conducting the testing, institutional bias toward or away from a particular piece or brand of equipment, and again the needs of those financially supporting them in their investigative capacity.

As with test direction, funding typically comes from three primary avenues: public agencies (law enforcement, medical examiner and coroner), plaintiff attorneys or victim's families, or defense attorneys, frequently funded by the insurance company who wrote the liability protection on the equipment. The same issue of perceived need, bias and limited scope previously discussed all apply to funding as well.

Finally, we must consider the problem of when testing occurs. The best time to examine and evaluate equipment is immediately after the incident occurs. The longer equipment sits, the higher the likelihood of data being lost. While rapid evaluation is conducted in some jurisdictions, more common current practice is that equipment is not examined or tested until the perceived "need" arises. This typically is defined as when a lawsuit is being contemplated or filed. Since it may be months before a suit is filed, the interval between the incident and testing is substantial. Further postponements are frequently caused by motions and disagreements between plaintiff and defense attorneys during the discovery process. It is not uncommon for equipment testing to be delayed by several years after the incident, making such testing much less effective and much harder to interpret.

Future Direction

It should be apparent that current practices are inadequate for the optimal level of information capture and maintenance with regards to post-incident scuba-equipment testing. We believe that the process could be improved, providing benefits to all constituent groups, by implementing a different process for such testing. This recommendation is not without its own challenges, specifically associated with training and funding issues. However, it may provide a stepping stone to a gradual change of a long-term plan that would accomplish the job even more effectively. Components of our proposal may be summarized as follows:

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- Public agency personnel should provide the direction associated with equipment testing. They generally are the most impartial and have the greatest training in conducting investigations. Generally speaking, law-enforcement personnel would probably be the most able to provide this function, but in some jurisdictions coroners or medical examiners may be in a better position to provide this direction.
- Equipment involved in incidents should be treated as evidence, not as personal property. Proper chain-of-custody procedures should be followed.
- Information preservation must begin at the scene: We must teach dive professionals and first responders the initial steps required to preserve data.
- Equipment testing should occur within 24 hours of the event.
- Testing should be conducted by an independent professional but overseen by law enforcement.
- Standardized testing procedures and protocols should be developed and followed.
- When indicated, manufacturers’ agents may be asked to participate, but if so should be directly overseen by a knowledgeable third party.
- All testing should be photo-documented using both still photography and video.

Chain of Custody

Different law-enforcement evidence procedures exist throughout the world, but there are certain fundamental protocols that almost all law-enforcement agencies adhere to. For an item to be considered a reliable piece of evidence, the following conditions must exist:

- A handling officer or agent must document the dive item at the time the item is collected. This usually involves documenting the item in a notebook or report at the time of collection and placing some type of evidence tag on the object. This documentation should include the manufacturer’s name, serial number, color and condition of the item, where the item was found or recovered and who had contact with the item before being secured by a handling officer or agent. In most jurisdictions, photographs are taken of items involved in fatalities even before the item is collected. This provides a visual image of the item when it is first found, collected or received.
- All dive equipment associated with the fatality should be held as evidence, as would be the case with any other object (firearms, knives, narcotics) that could have been involved in a fatality. Dive gear should be properly documented in a notebook, photographed and secured like any other relevant item associated with a law-enforcement investigation.
- Once the dive item has been collected, the item needs to be packaged or transported to a secure location in a manner that does not damage or change the item or its evidentiary value (e.g., allowing a regulator mouthpiece to be damaged in transport). Before placing the item in an evidence locker or room, the officer or agent will list the items held in either an evidence computer database or handwritten logbook. The information placed into the computer or logbook usually includes a description of the item, when the item was recovered, who recovered the item, the name of the decedent and a specific number assigned to the case.

- Placing dive gear into evidence solves several issues that arise if dive gear is held as “personal property.” Once in evidence, any piece of dive gear removed for any reason will be documented. This documentation includes when an item was removed, who removed it, why it was removed and when the item was returned to the evidence locker. Without this vital documentation or security, an item being relied on in court years later as “evidence” could be deemed unreliable. Placing items into evidence minimizes the chances of the dive gear being misplaced, lost, stolen or handled improperly by untrained individuals.

The above procedures could be simplified if the agency has only one dive investigator who is the only person who has access to a “dive-evidence locker” as compared to an agency that might have a large evidence room run by a specific evidence custodian in charge of many different types of evidence and cases.

Most of the time, the only gear that is retained as evidence or personal property is the gear worn or used by the decedent, but this possibly should include some or all of the dive partner’s dive gear as well. Items such as a dive partner’s computer can verify or disprove the statement of a partner. The partner’s dive computer could be more advanced and provide a better dive profile than the decedent’s dive computer. In out-of-air cases, the decedent might have used the dive partner’s octopus or bailout bottle, in which case that equipment will need to be identified and tested.

In all cases, every piece of dive equipment must have a documented chain of custody, especially if the fatality was found to have criminal or civil liability. All gear should be secured in an evidence locker until the equipment is determined to have no civil or criminal relevance or is ordered released by a court of law.

Evidence Preservation

Upon arrival at a dive fatality the investigator should interview any personnel that might have had contact with the dive equipment. This list includes dive partners, on-scene rescuers, bystanders, instructors, divemasters, lifeguards, firefighters, chamber crews and law-enforcement personnel. These interviews will provide the investigator with an idea of how the fatality might have occurred and what specific equipment testing might need to be done. These initial interviews also will help the investigator document any changes that occurred to the equipment prior to their arrival. This is vitally important because any findings that are based on altered equipment could lead to a wrong conclusion on why the fatality occurred. This means specific questions must be asked of on-scene personnel to determine what changes were made to the equipment and who made the changes. Any and all changes must be determined and documented.

Photographs of the dive equipment should be taken at the scene to show the condition of the equipment as it was found or recovered. This includes photographs of the cylinder, buoyancy compensator, regulator, gauges, dive computers and any other relevant piece of gear.

Before transporting the gear to a secure location, the investigator should document in his notes the type of equipment and the overall appearance of the equipment. The notes should also document any major issues that are apparent that could have led to the fatality. This includes noting specific aspects of the equipment that could change while the gear is in transport or waiting to be tested (e.g., the volume of gas contained within the buoyancy compensator).

If the cylinder valve is still on, the pressure of the cylinder(s) should be noted and then the valve turned to the off position after noting the starting position of the

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valve knob and how many turns were needed to close the valve. If the cylinder had been turned off prior to arrival and was not empty, the valve should be opened to note the cylinder pressure. If the cylinder was recovered empty or close to empty, the valve must remain in the off position for transport to conserve any remaining gas for analysis.

First-Responder Training

Equipment investigation begins before the fatality occurs. Training needs to be conducted for first responders on how to properly handle and document equipment that has been used in a dive fatality. This training should be geared toward rescue divers, divemasters, instructors, lifeguards, firefighters, recompression-chamber crew, law-enforcement personnel, U.S. Coast Guard personnel and dive boat crews. These are the personnel who will most likely have contact with a dive fatality and the decedent's dive equipment. If the decedent's dive equipment is altered without the handling investigator's knowledge, then any equipment findings could lead to a wrong conclusion or analysis.

First responders, instructors, divemasters and boat crews should be advised of the following procedures or similar adopted procedures if a decision is made to turn off the cylinder valve prior to the equipment being held as evidence.

- Record and photograph the cylinder pressure from the submersible pressure gauge with at least one other person as a witness.
- Mark the cylinder valve and cylinder, and then count how many turns it takes to close the valve. After the valve is closed, record the cylinder pressure again.
- If transport of the gear to a testing location will be delayed or the travel will be rough, tape the valve shut to prevent it from being accidentally opened during transport.
- Attach a tag to the valve with the date and time the valve was closed and the name and phone number of the person who closed it. The tag should also include the cylinder pressure noted on the gauge and how many turns it took to close the valve.

Similar procedures should be followed for any other piece of equipment in which the original status may be altered during rescue or recovery operations. These may include but are not limited to turning off dive computers; turning off lights, strobes, cameras or other battery-operated accessories; switching off rebreather electronics; rewinding or respooling line that may have come off a reel; unclipping accessory equipment; or removal of any equipment such as weights or accessories.

Timely Evaluation and Testing

Dive equipment needs to be examined as soon as possible after the dive fatality occurs, preferably within 24 hours. Even gear not used in salt water can be damaged if left wet in a dive locker. Metal parts can rust or freeze, rubber can deteriorate, and plastic pieces can be break. Data contained on certain gauges and in dive computers could be lost if the batteries were allowed to drain or become compromised. Dive equipment that has been left unsecured or allowed to deteriorate over an extended period of time might make later equipment evaluation difficult or even pointless. Testing a regulator used in the ocean that was left drying in a plastic bag would not render the same results if secured properly and tested immediately.

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Standard Test Protocols

Each piece of equipment associated with the dive fatality should be examined, evaluated and tested to make sure the equipment works as designed. Efforts should be made to locate any piece(s) of equipment that had been ditched or lost during the rescue phase of the incident. Without complete equipment, assumptions are sometimes made that might not be correct.

Evaluate the equipment in a manner that maximizes the information gained without sacrificing important information that will be needed later. Equipment should be examined in a systematic manner using established protocols that allows the investigator to examine each piece of gear as it relates to the other pieces of equipment as a functioning life-support system. Later in the testing process each piece of equipment can be tested individually.

At the end of the evaluation process, the investigator should have notes and photographs of each piece of equipment and how that equipment was connected to, or interacted with, the other gear being tested. This includes the size and volume of items like the cylinder and buoyancy compensator to the smaller pieces that make up the equipment like the O-rings.

The investigator should also know if the equipment was owned by the decedent, borrowed from a friend or instructor, or rented from a dive shop or boat. Without this basic information, it would be difficult to ascertain when the gear was purchased or last serviced or who is actually responsible for the gear being used. If possible, purchase receipts and maintenance records should be obtained on all serviceable pieces of equipment.

Certain pieces of equipment might need to be tested in the water and at the same depth or pressure where the fatality occurred. For example, a regulator might appear to be working on dry land but breathe very wet while underwater. This could cause a diver to aspirate water, leading to panic. If this were not discovered, then the possible trigger factor would never actually be known.

If possible, regulators and other types of equipment should be tested at the same cylinder pressure noted when the fatality occurred. They should also be tested in multiple orientations while underwater.

Only qualified personnel in an environment that can be reasonably controlled should do underwater testing. Safety divers should be deployed during the testing process. Items like regulators should be decontaminated and then placed on a pony bottle, unless the quality of the gas in the original cylinder has already been verified.

Any camera or video equipment that was being used by the decedent, dive partner or person in the dive party should be obtained or the contents downloaded as photographic evidence. The photographs or video images should be downloaded as soon as possible to gain a better understanding of what occurred before, during or even after the dive. A video showing divers fighting against a strong current could be very helpful in understanding why a middle-aged diver with a history of heart disease was later found dead on the bottom. The images could show the gear being used by the diver and what that gear looked like before being removed during the rescue.

Similarly, any dive computers worn by the decedent and possibly the dive partner should be downloaded as soon as possible. A detailed dive profile will often provide information that makes a reconstruction of the events leading to the incident much more likely.

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Appendix E of these proceedings contains sample equipment evaluation forms to aid in the equipment testing process. Forms for both open-circuit and closed-circuit scuba equipment are included. The closed-circuit forms were drafted with input from many individuals. Gregg Stanton provided the initial effort and draft with further input on subsequent drafts provided by Joerg Hess, Kevin Gurr, Mike Ward, Gavin Anthony, David Cowgill, Jon Conard, Jeffrey Bozanic, Richard Vann, Petar Denoble and others.

Manufacturer Agents

If a manufacturer is needed in the testing process, the equipment should be tested in the presence of, and under the supervision of, the assigned investigator. It would also be prudent to make a video of any testing or evaluation done by the manufacturer so it could be reviewed later if needed. The manufacturer's agent should be asked to provide a running commentary of all actions taken so the record is clear upon later review.

Photographic Documentation

High-quality photographs should be taken of each piece of dive gear at the testing location. This should occur prior to any equipment manipulation. The photographs should clearly show any gauges, hoses, connections, buckles or attached gear and note any damage. There should also be photographs showing the equipment manufacturer's name, model and the serial number.

The testing process begins by taking detailed notes and high-quality photographs of each piece of equipment as it has been found. Make sure to have multiple photographic views of any piece of equipment that is damaged, is thought to have been a factor in the fatality or is found connected or assembled incorrectly (e.g., low pressure hose not connected to the buoyancy compensator).

All testing and evaluation procedures should be documented by video. Such documentation may be used to resolve discrepancies or ambiguities in the actual testing practices long after the tests have been completed.

Long-Term Future Possibilities

We recognize that the proposals above do not offer a complete solution to the problems and issues facing us today. We regard them as an interim solution that may improve the current practices. It is expected and desired that such practices continue to evolve and improve. Some possibilities include the following:

1. *Formation of a national investigating authority.* This investigative body might be modeled after the National Transportation Safety Board (NTSB). A body such as this would offer the benefits of concentrating knowledge and experience in a single unit, which could be expected to quickly improve during a relatively short period of time. It could also offer the greatest resource efficiency by providing a centralized data storehouse (repair manuals, disks, downloading software, etc.) and capital equipment facility (test benches, ANSTI test machines, apparatus, etc.) in a single location without widespread or regional redundancy. However, the perceived need for such an agency is minimal, as the impact of scuba fatalities or injuries is not nearly as widespread as the need for investigation of national transportation issues. Scuba diving does not impact a broadbased citizenship like transportation does.
2. *Establishment of a nongovernmental organization (NGO) to coordinate and provide testing.* This could have similar benefits to the national investigative body considered above, but instead of being governmental, it would be supported by

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those interested in the information and results: divers and associated members of the dive community. Divers Alert Network (DAN) could be considered as a model for this suggestion. Because of the direct interest of the community members, an NGO might be more successful than a similar governmental agency. Challenges include a lack of funding, no universal acceptance, ownership and access of documents and findings, and problematic issues associated with post-testing requirements (depositions, law suits, court appearances, etc.)

3. *Vendor list.* A list of competent testing and investigative resources should be developed and made available to all parties involved in testing. Such a resource base might include core competency data and contact information for scuba equipment testing facilities, qualified individuals, scuba equipment manufacturers, test equipment manufacturers and governmental and NGO agencies involved in testing. Such a resource could be web-based and openly available. Challenges include designating an individual or group to establish and maintain the site, providing criteria for inclusion on the site and general acceptance of the persons responsible for maintaining the information.
4. *Information library.* A similar database could be established to provide documentary resources to persons or agencies responsible for conducting equipment testing. The primary resource on such a database might be a standardized evaluation protocol or protocols such as those provided in Appendix E of these proceedings. It could be expanded to include a broad library of manufacturers' repair and service manuals for different types of scuba equipment, notices of finding from previous investigations, courtroom and depositions documentation from previous incidents, operations manuals of test equipment and other similar articles. Challenges include the time and effort needed to amass such a collection, access security and setting criteria for inclusion. It may be that an organization involved in providing similar functions in the dive industry, such as the Rubicon Foundation, might be approached to fulfill this function.
5. *Qualifications determination.* We need standards that would qualify an individual, group or agency as testing personnel. Such a program might take the form of a certification or qualification evaluation, a grandfathering program or a training class. While we are unsure of the format, it is apparent to us that we need some type of criteria to qualify testing personnel. We may also need criteria that would prohibit certain classes of individuals from conducting testing. These might be necessary to prevent conflicts of interest, biased reviews or other currently unforeseen issues.

Conclusion

We do not suggest that we have all of the answers to the problems and issues facing the industry in the area of post-incident equipment testing. We offer some suggestions that we feel would benefit the industry, as well as a series of equipment-testing protocols for general use. It behooves all of us to continue to examine this issue, make improvements to such protocols and share information on equipment testing. Broad community input can only help us all.

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Discussion

DR. PETER BENNETT, UHMS: We have not really had, in the beginning of this meeting anyway, a documentation of the incidents of fatalities that we have. Certainly when I was running DAN and was involved with some of this data collection and presented some of it, I seem to remember that most of the accidents did not involve equipment. It was human error in using the equipment perhaps, not the equipment itself. I am wondering just how big a number it is. We are told comparisons with fatalities on the roads. Well, you have 45,000 deaths a year in the United States on the roads, and maybe 10 to 15 deaths in the United States in the diving world. So, obviously, resources are going to be very hard to obtain.

JEFFREY BOZANIC: That is a really good point. Steve made that point as well, and I did not mention that. The reality is that equipment is not generally the root cause of the incidents that are going on. Although it may be a contributing factor to many incidents, it is usually not the root cause. In fact, as Peter just mentioned, the reality is that pilot error is what typically causes most of the problems as it relates to equipment, either through improper use, improper setup or improper maintenance. Usually it is pilot error that causes the problem to begin with, improper dive practices. But apart from that, there are numerous incidents in which dive equipment has been directly contributory to the particular incident. For example, there was an incident off San Diego involving bent pins of an integrated weight system; the bent wires prevented the diver from being able to adjust the weights, resulting in an inability to reach the surface, causing a fatality. We have had buttons switched off by hydraulic machines underwater that have turned off life-support equipment. We have had valve disintegration or valve problems causing leakages. We have had torn drysuit problems leading to hypothermia being a contributing factor to fatalities. We have had improper use of diver propulsion vehicles or buttons not turning off on diver propulsion vehicles. In one case I worked on somebody was holding a DPV. Turned it on, it didn't work mainly because of where the switch was placed, pivoted on their hand, hit them in the forehead, is what we believed happened, knocked them unconscious underwater, and they sank to the bottom and drowned. But you are right, the majority of the incidents that occur underwater are not due to equipment faults themselves but may be related to the equipment in terms of other scenarios. And I don't have a good number for you. I have not looked at that particular issue. Even trying to do it in a small field such as rebreathers is really difficult to do. We have less than 200 fatalities to look at worldwide over the last 10 years. With most cases we do not have enough information to evaluate what is going on, and even when you do, the data capture is not good enough to be able to look at what is happening.

DR. JAKE FREIBERGER: In my experience, diving equipment problems are a small subset of most fatalities. What are the key questions you would ask during an investigation? When would you call in an accident investigation, since there are lots of times that we have an incident rather than a fatality? What are the things that we can use practically when we are consulting on these cases to decide that this is a case that actually needs an equipment investigation? Please address this for both open-circuit and rebreathers.

DAVID PARKER: I will do my best on at least one of those; I'll leave the second one for Jeff. In Los Angeles County any time there is a fatality there is going to be an investigation. The gear is going to be held as evidence. That is just not disputed at this time. So nobody has to request it; it is going to be taken care of. Then hopefully it is done correctly so everybody has that information. Other agencies are not quite that way. When it comes to — and the second part of your question, sir, I think was dealing with what DAN would do with that information or if they were requested?

FREIBERGER: No. We have a lot of diving incidents, and not all of them end up as fatalities. Some of them do. Most of them, in fact, are primarily medical problems or, like Mr. Bozanic said, operator error. But what would be the things that would push you to have an equipment investigation? Should we investigate them all?

PARKER: It is my belief, at least in Los Angeles County — I am tasked with that particular field now — that, yes, every time we have a fatality, the equipment is going to be tested. I could get a call tomorrow and be told that the gentleman definitely had a heart attack, but I am going to go through and test all of the equipment, including the gas, to rule out any other factors that might have contributed to that fatality.

FREIBERGER: Do you have an estimate of what percentage of the times that actually occurs?

PARKER: Sir, I have not been in the field long enough to tell you. I just know in the past year and a half there are at least three — of the seven fatalities last year, in three of them equipment had something to do with the death, either the flow-restricting orifice.... There was one gentleman who decided to place shoelaces on his integrated weight pouches, thus making them nonfunctional and then ran his cylinder dry. Those are things that the equipment had an effect on why he did not survive the incident. It was not an equipment malfunction, it was an operator malfunction.

BOZANIC: So that was about 45 percent of the incidents in a small sample set. It is pretty high, but I don't think it is generally that high. Your second half of the question was looking at rebreathers in particular. One of the things that we need to recognize is the fact that as technologies are developing, we know less about new technologies than we do older technologies. So we all have a fairly reasonable understanding of open-circuit dive gear and the things that happen with it, either deficiencies or the way it is misused. Generally the level of development within this part of the community is probably higher in terms of knowledge base than it is with new technologies. My belief is that with newer technologies, things like rebreathers or mixed-gas diving being done recreationally, that those types of incidents suggest that we should have a much more in-depth investigation into the incident and the equipment involved in general because we have the most to learn there. Our knowledge base is not as well established. There may, in fact, be numerous and significant unknown factors that are taking place and causing some of these fatalities. We are not going to find out what those are unless we spend the time looking at them. So with rebreathers in particular, my suggestion would be that we look at all of these incidents.

KARL HUGGINS: We have a very good working relationship with the sheriff's deputies on Catalina Island and the Emergency Services Detail (ESD) where Dave comes from. In terms of answering when an investigation should occur, one of the things we do is to contact ESD if we have a diver who has the potential of being a fatality. So if we have somebody brought in in cardiac arrest or somebody being brought in in respiratory arrest, they will be notified so they can actually start the investigation. Even though the person may survive, they have actually started the investigation right then because there is the potential that is there.

PARKER: Extremely helpful. Karl called the other day, and we were able to get things going much more quickly than if I waited for an official call after somebody passes away.

GORDON BOIVIN, U.S. Coast Guard: I find it intriguing that this morning collectively we are talking about equipment, and the sport is so heavily dependent on equipment, yet everybody has so far has said the equipment is not that big of a deal because it is not causing the problems. I have to back Dave up. We have crossed paths on the last two fatalities. What causes a 32-year-old physically fit male to die? He is on the bottom, and he is dead. If you do not look at the equipment, what caused him to have the heart attack? Truly and honestly, Dave and I have worked on a couple now, we have to get the equipment. Then the second point, one of the interesting things is the last case we worked on together, he meets the diver in the chamber. I met the commercial divers on the dock. The equipment is in two different places, all of a sudden in two different jurisdictions. At the end of the day when I turned around, the dive buddy walked away with the dive bag. So the dive buddy took all the personal effects and went home, and Dave was left with the just gear at the other end. It was kind of like, oops, we made a mistake. We work in a very close relationship between the LA sector and ESD. But when we step out of Los Angeles County and we go to Santa Barbara County, we walk in, the sheriff's department slides everything across the table and says, there you go, it is yours. But equipment, to me, is the root cause, some of it.

BOZANIC: Something that Gordon just said is something that I wanted to mention during the talk as well. It is not just the equipment being worn by the victim that needs to be examined. It is any of the equipment that was potentially involved in the incident. So, for example, if somebody signals out of air and goes to his buddy for air and that regulator gets offered to the person, the person puts that regulator in his mouth and perhaps there is a small tear in the mouthpiece. That permits water into the breathing chamber, he aspirates water and panics and bolts to the surface. It is any equipment that is involved. So when you look at this equipment and do an investigation into this type of incident, you also need to look at the buddy's equipment, and you may need to impound that as evidence as well because that may also have been contributory to the incident or the root cause of the incident and how things occurred. So that is also an important part of what should get looked at. It is not just the victim's equipment but that of the buddy as well.

GREG STANTON: Who in the past has determined the standards of our investigations? That may be the core issue.

BOZANIC: I think that for the most part that has been a haphazard development of practice, primarily developed by the insurance companies to either protect or pursue a particular claim within the legal arena. There really is no standard in terms of an investigative practice that is nationally accepted of which I am aware.

STANTON: Could the courts not be the ones determining that standard?

BOZANIC: That is what I am suggesting. Right now it is being done through the legal process. What I am suggesting is that is not the best way because it is not looking at the global needs of our community, which is development of dive safety.