

Safety Considerations in Undersea Life Support
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Abstract

Undersea life-support responsibility has not yet been clearly defined in available diving literature. Consequently, full understanding of the scope, problems and gravity of such responsibility sometimes escapes individuals who are responsible for life-support decisions. The definitive effort described in this paper is needed to improve awareness so that such responsibility may be better evaluated for its true contribution to the success of the diving industry and so that this responsibility may then be more judiciously placed and supported.

Some facts of life-support in diving:

1. Optimum safety in undersea life support is to stay out of the water
2. It is indisputable that absolute safety can only be approached and never quite reached.
3. Once a good general pattern of safety is designed to surround each hazardous exposure, actual safety is a function of the recognition of, and judgement on, the acceptability of the remaining degree of risk. Both the ability to "recognise" and the "judgement" required demand a high degree of expertise.
4. The need for life-support expertise exists wherever life is jeopardised by any intentional deviation from ideal existence.
5. Acceptance of self-risk is, to a degree, an inherent human right. Acceptance of risk to others is not. Where then should the responsibility for such decisions rest and upon what criteria should they be made?
6. The basic assumption in this Qualitative Discussion is PRIMUM NON NOCERE.

Facts Concerning the Diving Industry

1. It exists to successfully accomplish work underwater.
2. It is not successful if it negligently costs a man his life in the process.
3. It follows, therefore, that successful work is dependent on successful life-support.
4. Life-support is therefore the keystone of the diving industry.

Webster's Seventh Collegiate Dictionary omits the term "life-support". Thus it is left to the individual to interpret its meaning. Such vagueness constitutes a danger to the diver and is thus a detriment to success of the industry. This paper presents one man's opinion of the realm and responsibility of a senior life-support specialist. Hopefully a resultant debate and controversy will evolve a clear definition acceptable to the diving industry. Success in the industry to date is in large measure due to the inherent perseverance of the many undersea Life Support experts who often

function without title or defined responsibility, for lack of a clear definition of their specific task in the scheme of things. They are the individuals whose instinctive life-support motivation and vast experience surpass that of the ordinary working diver by such an amount that it nets them the humanitarian obligation to advise both the diver and senior management of their evaluation of the relative risk of any undersea human exposure. They cannot stand by and let an accident happen when their experience indicates that one is probable. They are the individuals in our industry best qualified to judge how safe is safe enough. A key point is that they are making that judgement on behalf of another. They must be recognised for their full value to our efforts and they must be supported accordingly.

Our hypothetical specialist needs no definition to understand what he is obliged to accomplish. His task is instinctive by this time and his surveillance and reactions are automatic. Accordingly, this discussion is directed to the balance of individuals peripheral to but influencing his task. More specifically, it is directed at individuals associated with diving who are specialists in associated fields and who would assume, or presently do possess (aware or otherwise), a degree of responsibility for the life and well-being of a diver. Included would be :-

Senior management	Inventors	Supervisors	Technicians
Administrators	Designers	Divers	Certifiers
Salesmen	Engineers	Tenders	Instructors
Scientists	Doctors	Foremen	Chamber Operators

Human error is the weakest link in the "safety" chain, for it has clearly shown itself to be such in Life Support accidents. The opportunity to make a fatality-producing error rests with this surprisingly large line of "responsible" people, and a specialist in life-support is well aware of it. Inherent in all the above should be a strong moral responsibility towards the life of the diver. When a fatality occurs (as it will), all individuals down the line own a piece of the responsibility and they must be prepared to face it. We must be prepared to look within ourselves to know that we have done everything in our power to fulfil the obligation we acquired when we assumed the responsibilities of making a life-support decision. All make decisions effecting the well-being of the diver. Preoccupied with their specific realm of responsibility, where they are expert, there is a natural tendency to overlook the existence of another equally significant speciality (that of Life Support) which exists in part to help keep their decisions safe and the program productive.

It is often assumed that the diver is that specialist: indeed it will always remain his prerogative not to dive. However, a diving school graduate with a year's experience is a diver through his experience remains lacking compared to the 20-year specialist. He often needs protection from himself. He should not be taken advantage of.

Senior Management is held responsible for selection of personnel. When considering hiring personnel for life-support responsibility they must be particularly aware of the well-founded statement "fools rush in". Foolishly, individuals possessing a neophyte's experience in diving, overconfident of their little knowledge, are often

quick to assume life-support responsibility, not fully aware of the significance of their action. Management must therefore look deep and long at the qualifications and experience of individuals in whom they would place life-support responsibility; otherwise they jeopardise their personal legal position, the company, the success of undersea efforts and last but not least, the life they wish to support. Having made this analysis, and selected the expert, they must support him.

The chain of responsible individuals must continually weigh the factors which are detrimental to safety against their value of a man's life. For instance, the *Inventor* conceives of devices or systems with which to push back the diving frontier: the greatest steps ahead usually involve the greatest risk of life and he must weigh the value against the risk. *Designers* are constantly confronted with a lack of existing "off-the-shelf" components and must decide whether to utilise an "almost safe" one or undertake the difficult and costly development program necessary to design a safe component. Economy and expediency constantly test the *Engineer's* value of another human life and he must be aware of this continuing process. *Salesmen* all too often are tempted to sell products or services which are "just a little" beyond the safe state of-the-art, and thereby incur increased risks.

The greatest responsibility of the lot rests on the field diving *Supervisor* or dive director. He is in the best position to prevent the mistakes of others from perpetrating an accident. He is also the most apt to be plagued by unrealistic innovators, inexperienced designers, careless engineers, unreasonable bosses and customers, and daring divers. Effectively he is the life-support expert.

The likelihood, then, of collecting a large chain of decision-making people, all of whom possess the right attitude towards diving safety, or life-support is rather slim. Here then is where the expert's attributes should be applied.

Definition of Undersea Life-Support Specialist

Between the diver and the many individuals who make decisions affecting his safety there should exist a knowledgeable specialist possessing safety responsibility and experience of a high degree. He must function primarily on the diver's behalf, accepting or rejecting decisions made by those less informed in that speciality, ie. undersea life-support. Such a safety structure will be seen to be fully in the best interests of all concerned. Hopefully, the following insight into the modus operandi of one man who has specialised in many years in the specific area of undersea life-support will serve to inform and thus temper decisions of those who are not so specialised.

The most important aspects are the least tangible. Life-support is an instinctive human characteristic when applied to oneself. It may be overdone by the ultra-conservative or handled carelessly by the brash. When applied to others it can range from valuing another man's life more than your own, to manslaughter. Responsibility for another human life is not lightly accepted by most people, particularly those best fitted for the task. Why should man become involved in a field where life is risked every day? Because man must exploit the ocean's resources for survival. And if it must be done it should be the responsibility of those who are best prepared to minimise the risks in achieving the goal.

Best Prepared

Unfortunately today one cannot receive a masters degree or doctorate in undersea Life Support. No training programs existed a few years ago to fashion broad-based life-support experts. The current new programs emerging at forward-thinking universities have only the most meagre teaching materials. Text books have not been written yet. Even when they are, it will take years of post-graduate practical field experience to produce qualified undersea life-support experts. In ten to fifteen years good credential carrying, experienced experts may be available. Until that time we must proceed cautiously with the best available experts, who are experienced but necessarily self-trained. To portray such experts better we must examine their position, motivation, criteria for judgement and attributes.

Distribution of Life-support Responsibility

Position

Every decision maker owns a piece of the responsibility, though this is most highly concentrated upon two main individuals; the one who fits the description "senior management" and our ill-defined life-support expert (senior operations supervisor). The first is usually senior in management experience, the second in diving experience. The first is held responsible for selection of personnel and delegation of authority to those who hold major Life Support responsibility, the second is held responsible by the diver, the diving industry, his peer group and by senior management. The first has the full authority to act commensurate with his title and it is he who grants the degree of authority held by the second expert. It can be great or small depending on the opinion of senior management ... and of the diver. The diver authorises both senior individuals in effect by electing to do the dive requested of him. He will form his opinion of the degree of risk by examining the situation against his own background experience. He relies on the opinion of the most senior diving personnel to also evaluate the risk on his behalf against their much more extensive background and to advise him of their opinion. This advice may be implied; when such senior operation personnel allow a dive to take place they are in effect endorsing the exposure as safe enough in their opinion.

The thought process of the senior operating personnel in estimating the degree of risk to be encountered in each new exposure could fill a book. He automatically, almost subconsciously, applies his 20 years of experience and acquired knowledge. He has formed a reliable estimate on each piece of equipment the diver will have to rely on. He has his own personal opinion of the diver, his capabilities, weakness, experience, reliability, nerve, intelligence, and more. He must know the characteristics of each member of his operating crew as well as of the diver, so that he can estimate the probability of them making a mistake. He trusts no one implicitly, though some more than others. Then there's that exposure. Every dive is different in a thousand ways from the last one. Crane operator new on the job/diver looks nervous/reck operator has home problems/bank pressure is lower than usual/hose is frayed a little/compressor sounds different/storm coming/sea rising/and on and on.

A dive is a very complex program with thousands of variables, all of which I must be considered for their potential contribution towards or away from added risk. The trade-offs are not documentable nor quantifiable, thus the end product is knowledgeable opinion.

Our expert's judgement is not governed by granted authority alone. Far from it. For reasons we shall discuss, he cannot stand by and let a fatality occur because management would not supply adequate equipment/management hired and incapable individual/the diver insists on overstaying his bottom time/the diver wants to omit decompression etc., etc. There are many instances where he must act to protect the life of the diver in spite of management or in spite of the diver's insistence on killing himself through ignorance. The "authority" to act in such instances stems from within. He must choose to take unauthorised action on his own or stand as a major contributor to a fatality. If he fails to act when his experience and knowledgeable consideration indicate a necessity, he jeopardises a life, the job, his management's and his own legal position, his professional standing and career and, hopefully, his conscience.

Senior management will seldom authorise an employee to take action contrary to management decisions. A diver will seldom authorise the dive supervisor to take action against the diver's wishes. There is however a trend in the military where a subordinate can refuse to follow an order when he believes it to be contrary to his personal human values. A dive supervisor must have some right to prevent a dam fool diver from committing suicide on the job! The legal position of our hypothetical life-support expert badly needs publicised definition.

Prerequisites

To make the next point I must borrow a pilot's phrase well applied to diving "There are old divers, and there are bold divers, but there are no old bold divers". A diver's Attitude must be right for his survival and so must that of his life-support expert.

Diver pre-requisites are significant because the expert a life-support must be completely familiar with them through personal experience. An individual may become expert at some facet of life-support, but one cannot achieve the breadth of understanding without having been there. Experience, more than ever in diving, finds no substitutes. Diving is, by its very nature, an intimate experience. The written word cannot adequately convey all the subjective sensations, feelings, fears, or joys, of a solitary diver deep in the ocean. But experience is a great teacher only if the individual has that particular ability to perceive most of the possible results of a given course of action and thus anticipate the problem areas before they appear. It is primary to any safety program and indispensable in the life-support expert.

The capability most conducive to expertise in this field is anticipation based on EXPERIENCE. Whenever a highly paid diver or life-support expert elects to forfeit that pay and not to expose himself to a set of conditions which he knows have previously resulted in a fatality, his decision is thus based.

The ability to anticipate, combined with extensive life-support experience, best allows the prevention of the "classic set of circumstance" which always precede a diving fatality.

The expert is continually called upon to make trade-off with life at stake. More specifically, with someone else's life at stake. He is expected to be the one who would quickly recognise the lack of a pattern of safety and have the courage of his convictions to stop the job. This has been done on jobs when down time cost \$1,000

per hour. On such occasions, lack of precedent left only a personal conviction that the pattern of safety was inadequate. He is the key man obliged to see that the safest set of conditions obtainable within the limitations and requirements exists; then one who further weighs the need against the remaining risk. That statement bears further examination. Based on his experience and technical knowledge he examines each new exposure and will balance the degree of risk to a diver's life against the need to dive. When risk exceeds need he will not endorse the dive. When the need becomes greater or the risk becomes less, he will. Unfortunately, quantification of these relative values is almost totally impossible, thus judgement must be applied. He must be completely objective. He must apply that unique characteristic enabling him to avoid consideration of his own well-being. In other words, he must be prepared to oppose the boss, the customer, the diver or even quit the job before becoming party to a negligence caused fatality.

Risk

Every diving expert has a slightly different opinion of risk expected on any given exposure. They may also differ on their value (weight) of the diver's life. Most place this value high, for moral and/or legal reasons. It is highly desirable that the "expert" be motivated by a real feeling of moral responsibility, for then his decisions are likely to be more obvious and clear-cut than those made by one who may have his attention diverted by analysis of his legal position.

The law represents society's insistence upon conduct of affairs in a reasonable moral framework. Thus from the diver's viewpoint he would prefer his "expert" possess such values inherently rather than by force of society or law. Bear in mind that most of today's "experts" are or were participating divers and thus are conditioned to accept self-risk. Fortunately natural elimination of the brash and incautious tend to result in the more conservative divers remaining influential in the field. This is great only if the diver-come-expert will not allow another to accept risk which he would not have accepted for himself. Suffice it to say, the estimation of "weight" in the life-risk basket is a most difficult task, particularly under pressure.

Need

Dollars, personal gain and profit clearly motivate the individual diver. He requires no "need" beyond immediate gain, but what of the guiding expert? Analysis of the diver, while considering the admonition "do unto others as you would want done unto you". The "expert" responsible for the diver's well-being must not be the type of individual who would subject the divers to more risk just to make more money for himself, or to improve his position with the company, or for expediency, or because the customer will be angry if he doesn't, or because he's hung over and not too sharp in his thinking, etc. The expert's acceptance of responsibility for others must be based on knowledge, vast experience, a demonstrated high regard for life other than his own, a high level of personal integrity, and a pointed independence from the insidious influence of the anti life-support pressures normal in such circumstances.

Perhaps ANTI LIFE-SUPPORT pressures require elaboration- Anything that lands in the need basket constitutes a force urging the acceptance of more risk for the diver. Money, expediency, schedule, boss pleasing, customer pleasing, personal advancement, breaking records, pseudo science, publicity and many more pressures can operate.

Unless resisted, such forces can be fatal. Very few such "needs" are valid reasons for accepting risk for others. A valid case can be made under some circumstances, such as the advancement of science or military needs for the protection of one's country, man's need to exploit the resources of the seas for food and energy, the training of divers to meet such needs. Such may reasonably motivate an expert.

The best motivation is the realisation that their task, well done, satisfies their own personality and career objectives, the exploitation of the sea. Risking another's life for a dollar is improper motivation and explicitly forbidden by the Nuremburg Code.

Dives made in hyperbaric facilities may require special consideration, as they often deviate from proven accepted procedures, eg. decompress a little faster, stay a little longer, go a little deeper, try a new mixture. Such dives can sometimes be classed as human experimentation and require the highest in human ethics in their control. Should our military, scientific and commercial exposures be made under lesser ethical standards? Acceptable degree of risk in human experimentation is a matter between the subject, the experimenter and a knowledgeable medical review board convened to advise senior management. Here it is difficult to define the degree of responsibility retained by our expert for the safety of the diver. He should not interfere lightly. He must be as well informed as possible to form a personal opinion of risk and need. If he believes risk outweighs need he should appeal to the experimenter, and if this fails, to senior management. He retains the right to disassociate himself from the dive.

Profit

"Someone must chop the firewood or the house will be cold and we'll all suffer. Indeed the axe may slip but it's a chance someone must take." A conscious trade-off, with a possible threat to one weighed against the good of several. Oil from undersea wells involves a credible reason for a measured risk for some for the good of many. We'll make a profit if we do this dive, and profit is the lubricant for the wheels of industry. If the offshore oil companies cannot profit, they will cease to drill; if the diving contractor cannot profit, he will no longer offer his services; if the equipment manufacturer loses money, the equipment is no longer available; etc. Conclusion: the profit motive is and must remain a prime and legitimate mover on the "need" side of the scale. But the divers would not want the "expert" responsible for their safety to accept risk for the diver to enlarge the profit of the expert, or anyone else. He would want him to function on his the diver's behalf. This is not really in conflict with industry objectives, for if he fails the diver he has also failed his employer. Million dollar diving programs have crumbled after a single fatality. The monetary cost of death is considerable and tends to upset the profit picture. The experts job is to support life in spite of the anti-life-support pressures normal to the everyday business world.

Extraneous Pressures

Supervisory titles exist in the diving field which now warrants some examination in quest of the "expert". He may be titled dive supervisor, dive director, master diver, diving officer, test director, or other. All these titles imply the holder bears a large part of the responsibility for the life of the diver. In fact, it is their

first obligation in peacetime activities. However, a question must be asked; can these people ethically judge "risk against gain" for others while they are heavily pressured by anti-life-support considerations urging them to accept a little more risk for the diver? Would it not be more in the interest of everyone involved if the "expert" were charged with life-support responsibility alone ... and then supported by all in his decisions? He, the expert, is then free to judge risk against the more humanitarian "needs" for the exposure, with another responsible for profit and loss of the job. Both individuals should have a good understanding of the other's problems. This difficult division of responsibility should be pondered by other specialists in the field, by guardians of the legal aspects of things by owners or directors of undersea operations, and by insurers of such activities.

Such a division would be a desirable enhancement of our undersea efforts. The title "Life Support Professional" would then designate an individual who by his profession is sworn to standards equal to the medical profession's Oath of Hippocrates. He would be one whose experience, philosophy and intellectual/emotional make-up may be reasonably expected to result in fair decisions in the responsible position he is to fulfil. No existing group could examine and certify such individuals. no counterpart to AMA exists and not enough interaction among the various branches of diving is underway to hope for such a commonality of opinion at this time. Perhaps OSHA could enforce some regulations but it is difficult to conceive the criteria they would use to select the examining group.

Certification

It has been shown that the individual functioning as an undersea life-support expert is in a position where his decisions radically effect the safety of individuals other than himself. his 'experience' is being relied upon to materially reduce the risk while still getting the job done. Much precedence exists for similar responsibility, eg. doctors, pilots, ship captains, bus drivers, diving instructors, etc. However a significant difference exists between this group and our hypothetical life-support expert. All the others are licenced for their responsibility by peer group examination and carry credentials to prove it: it would greatly enhance the standing authority and recognition of our expert if he could be so credentialled.

Challenge to the Diving Industry

Since the "life-support expert" exists under various titles right now and functions more or less as described herein and represents probably the single most important force towards the success of our industry, then the industry must answer some questions. Who is qualified to advise a diver and/or senior management what set of conditions constitute acceptable risk in response to a given need in scientific diving/commercial endeavours/non-wartime military dives/diving apparatus design/support equipment design/diver training? If such a professional is to become accepted, how do we indemnify him, qualify and certify him, clarify his task, support him; what is his legal and moral position and how can he function in the best interest of the industry.

I have been pondering, in writing his paper, philosophical/ethical aspects of life-support professionalism. If these observations provoke some response, pro or con, amongst those readers familiar with this rather specialised field of human responsibility, then operating and management personnel will have a dialogue benefiting ourselves and our industry. The thrust of my observations is not to regiment procedures or to minutely classify personnel prerequisites but rather to grab renewed attention to the responsibilities we all face in conducting undersea work.

Policy Code for Hyperbaric Exposures

1. Participation of diver subjects shall be on the basis of uninfluenced voluntary consent.
2. The dive should be such as to yield fruitful results for the advancement of diving unprocurable by other means, and not random and unnecessary in nature.
3. Based on credible data, the dive should be so designed that the anticipated results justify the performance of the dive.
4. The dive shall be so conducted as to avoid all unnecessary physical and mental suffering and injury to the divers.
5. No dive shall be conducted where there is an a priori reason to believe that death or disabling injury will occur.
6. The degree of risk to be taken should never exceed the humanitarian importance of the problem to be solved.
7. Proper preparations shall be made and adequate facilities provided to protect the diver against even remote possibilities of injury, disability or death.
8. The dive shall be conducted only by qualified persons. The highest degree of skill and care shall be required.
9. During the course of the dive the diver shall be required to bring the dive to an end if he has reached the physical or mental state where continuation of the dive seems to him to be impossible.
10. During the course of the dive the Dive Director or Medical Director must be prepared to terminate the dive at any stage if he/they has reasonable cause to believe that a continuation of the dive is likely to result in injury, disability or death of the diver.

SUMMARY

The Welfare of individual human beings takes precedence over every other consideration.

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Editorial, continued from page 3

by whim.

The Manna meeting was successful. One unexpected lesson was that our medical orientation is to the dramatic so that there was equipment to cover the in-water treatment by oxygen therapy of DS but no preparedness for ENT problems. Common things are commonest! Perhaps there is a tendency to forget "minor" problems, the bane of the many, through interest in the dramatic rarities (and may they remain rare). If we make diving safer and more comfortable for the "paddlers" the resultant increase in understanding of mammalian physiology may even save the "deep boys". Hypothermia is an excellent example of a problem neglected till recently because it was thought stupid to complain of discomfort. Good diving records are the basis of further safe progress and Incident Reports are the alarm bells. It is up to us all to play our parts in this venture into the "baric" jungle.