The silent witness: using dive computer records in diving fatality investigations

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Abstract

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Downloaded data from diving computers can offer invaluable insights into diving incidents resulting in fatalities. Such data form an essential part of subsequent investigations or in legal actions related to the diving incident. It is often tempting to accept the information being displayed from a computer download without question. However, there is a large variability between the makes and models of dive computer in how the data are recorded, stored and re-displayed and caution must be employed in the interpretation of the evidence. In reporting on downloaded data, investigators should be fully aware of the limitations in the data retrieved. They should also know exactly how to interpret parameters such as: the accuracy of the dive profile; the effects of different mode settings; the precision of displayed water temperatures; the potential for misrepresenting breathing rates where there are data from integrated monitoring systems, and be able to challenge some forms of displayed information either through re-modelling based on the pressure/time profiles or by testing the computers in standardised conditions.

Key words
Diving deaths, scuba accidents, investigations, computers – diving

Introduction

In their review of recent changes in diving fatality investigations, Edmonds and Caruso highlight the types of possible information that can assist inquiries through downloading dive computers.[1] We agree fully with the authors that data retrieved from dive computers can generate an indicative recording of the incident dive and, in most cases, the preceding dive history. We also agree that these records can be of extreme value in incidents where the diver dies alone and/or where there are conflicting reports of the incident dive. However, we would urge caution in how these data are accepted and interpreted. In particular, we should like to highlight areas where the accuracy of the information produced on download requires additional analysis. Whereas some of the points we raise could be considered pedantic, they are all relevant to interrogations that have taken place during Fatal Accident Inquiries (Scotland), Coroner's Inquests (England/Wales) or related legal cases.

Handling the victim's computer

On receipt of the dive computer, it is standard practice to make a full photographic record of the unit. Where there has been a delay, new batteries may be needed in order to begin any investigation. This may affect the quality of the downloaded information and needs to be referred to in any report produced; it may also result in a total loss of data. If the computer displays time, then a comparison is made between what is displayed and the actual time. Many computers will store some dive information that can be accessed without downloading the unit. However, it is mainly with downloaded data that difficulties with interpretation could occur. In general, most downloads provide a summary logbook of the diving history and more detailed information on the actual dives performed. The dive computer's logbook information can be relied on to give a good overview of the dive history preceding the incident. Invariably, most computers will store at least the basic parameters of the dives (date, maximum depth, duration, start and finish times); some store much more detailed information, including full dive profiles, although the volume of stored information does vary between models.[2] The initial checks of the computer's time clock against actual time will give baseline information on any differences that could be expected on download. In a small number of instances, the times on the dive computer were altered to the time of the computer onto which it had been downloaded; variations caused by daylight saving changes should also be checked for. It is obviously important that each computer is assigned its own logged file, but overwriting other files, to produce ones contaminated with data from multiple downloads, is possible using some of the proprietary software programmes.

Influence of mode settings on data

Most dive computers have several mode settings that can be adjusted before diving to show: whether seawater or freshwater is being dived in; the gas mixture being breathed; the level of conservatism being applied and the altitude of the dive.[2] All of these user settings have the ability to significantly alter the relevance of the data displayed to the actual incident.[3] It is not always straightforward to locate the user settings from a download; there is considerable variation between models and manufacturers and the information may either be with the individual dive information or in the summary logbook.

The dive profile, displayed as a simple depth/time profile, often attracts the most attention in any investigation as it presents an understandable visualisation of the incident dive. There are a number of issues related to the accuracy of the profile information recorded and displayed, but one of the main points to address is the accuracy of the depth recordings themselves. Nearly all dive computers measure only pressure and time. Usually the pressure sensor is temperature-compensated and highly accurate. However, calculating accurate depths of water from pressure recordings is not a simple task and is influenced primarily by the density of the water being dived in (temperature will also have an effect but this is much less than that of density). Dive computers can only convert the pressure measured to a depth estimate based on whatever water density the computer has been calibrated to. The calibration range and so the estimated depth cannot always be relied on to present an accurate record of the actual dive depths.[4] Whereas the variation in estimated depths will not affect the decompression information displayed by the computers (decompression obligations are calculated using the pressures recorded), caution should be employed when using computer depth to make decompression table-based comparisons or when using the integrated profiles to calculate relative decompression stresses.

Variations in recording and display of dive profiles

There is considerable variation in how different dive computers record and display the profile information.[2] This may cause difficulties in deducing an accurate profile of an incident dive. Central to these difficulties is understanding how the data are being displayed. Where the display is based on the maximum depth reached during a recording period, it is likely to give a relatively accurate record of the descent (until the descent is arrested) but a time-delayed record of the ascent (Figure 1). Ascent and descent rates will be more accurately displayed by computers that record the depth at the end of the recording period if no opposing changes in depth occur during that time; computers that record average depth values for each period provide little accurate profile information. The accuracies will also be affected by the length of the recording period. With relatively long recording intervals, it is possible that a significant depth excursion upwards in the water column could be missed entirely by computers recording only maximum or final depths, and the expanse of the excursion would be under-represented by computers measuring average values. However, it might be possible that an unrecorded depth excursion could still register an ascent rate warning and it is not uncommon to see ascent warnings on near horizontal profiles. But care should still be taken in interpreting the warning as an unrecorded depth excursion; ascent warnings can also be generated simply by the diver lifting their dive computer up to study.

In comparing more than one dive profile from the same incident dive, it will always be difficult to state the positions of the divers relative to each other with certainty. Examples of this are divers in a group ascending a shot-line together. When the dive profiles are compared, it will appear as though the divers were separated because of the different depths the divers were at when the recordings were made. These differences are then magnified if different models of computer are used that record and display depth differently, or convert pressure to depth differently. An opposite example is of two divers swimming around the hull of a wreck or a relatively level seabed but in different directions. The profiles could suggest they were together for some of the dive because of the similarity in the depths recorded.

Water temperature estimation

There is a high probability that the water temperatures displayed on dive computer downloads are linked in some way to the temperature-compensated pressure recorders. There is no evidence to support that temperature is being measured directly by computers and no information on how the measurements displayed are being derived. As a result, there is considerable variation across dive computers in the accuracy of the temperatures recorded in downloads.[4]

Air-integrated computers

Breathing rates can be calculated from downloads by using some measure of volume of gas breathed, corrected for ambient pressure derived through an integration of the dive profile. Sometimes, there will need to be an assumption, with confidence limits, of the volumes of gas consumed based on simple pre- and post-dive contents. There is likely to be a more accurate assessment from downloads that display information from dive computers that are integrated with a cylinder pressure sensor. The first 1–2 minutes of a dive profile will most likely yield erroneous breathing rates. This can be because of the delay in some computers in starting to register a dive; some computers undertake start-up checks for up to the first 80 seconds of a dive. Where the temperature of the water is less than air temperature there will likely be a concomitant drop in cylinder pressure that could suggest higher than actual breathing rates. In all cases, breathing rates should be presented at body temperature and pressure, saturated (BTPS) and not at ambient temperature and pressure (ATP). Thus breathing rates implied from pressure-corrected loss of cylinder content against time should be multiplied by:

$$(273 + 37)/(273 + \text{ambient water temperature } ^{O}\text{C}) \qquad (1)$$

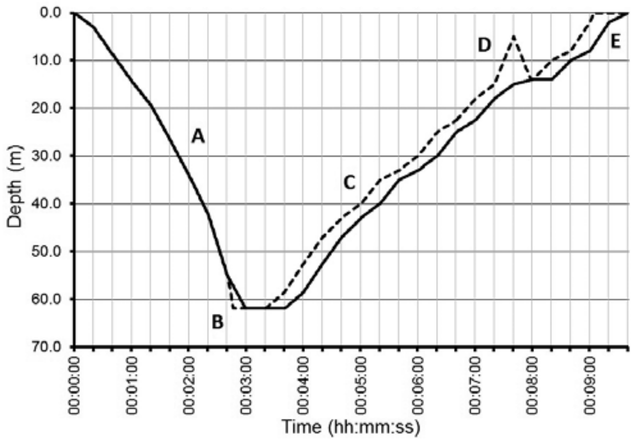
Where cylinder pressure recordings are more frequent than breathing rate, some form of rolling average will have to be employed to generate meaningful results.

Display of 'physiological' data

Dive computer downloads often present differing forms of 'physiological' data such as the diver's temperature,

Figure 1

A downloaded dive profile constructed from a real diving incident recorded and re-displayed by an UWATEC Aladin Ultra dive computer (solid line). The hashed line gives a different interpretation of what the actual dive profile could have been, based on the known fact that this model of computer displays profile information made up of the deepest depth estimate recorded during every 20-second period. With this recording format, it is unlikely that the displayed and actual descent profiles will differ if uninterrupted (A). One interpretation of the diver's actions in reaching the maximum depth is that they were in control and slowed their descent (B); however, they could have been in free-fall with the maximum depth reached much earlier during the 20-second recording period (B). In this type of computer there will be a near 20-second delay in the profile displayed during the ascent (C). Rapid ascents and descents in the water column lasting as long as 39 seconds in this case (D) could be missed off a displayed dive profile even though an ascent alarm may be indicated. Surfacing times on a display may be nearly 40 seconds later than the actual time of breaking surface (E).



breathing rate, microbubble formation, and the saturation levels in the tissue compartments. It is never clear how relevant these data are to the diver or how the levels are being calculated. A report of a computer download often has to discuss these data as they may appear pictorially on many of the figures being presented. However, it is often safer to dismiss these as indeterminate data and instead recalculate using probabilistic DCS modelling or some form of cumulative analysis (nitrogen loading or pressure root time) based on corrected integrated dive profiles.[5,6]

Laboratory and re-enactment testing

Dive computers can be tested in the laboratory or in incident re-enactments.[1] Bench testing can be relatively straightforward: e.g., comparing the accuracy of the unit's internal clock, or calibrated pressure exposures to validate the relative accuracy of depth estimation. Using the incident computer in a re-enactment helps to evaluate whether downloaded information accords with the information that was available to the diver at the time. However, with some models, it is important to realise that subsequent test dives may put the stored incident dive data at risk of loss.

Conclusions

Downloaded data from dive computers may seem to display incident dives accurately. However, the data are open to different levels of interpretation that can be challenged in the legal setting. Anyone using such downloads in fatal inquiries and/or related legal cases should be acquainted fully with the operational limits of the model under investigation.

References

1 Edmonds C, Caruso J. Diving fatality investigations: recent changes. *Diving Hyperb Med*. 2014;44:91-6.
2 Azzopardi E, Sayer MDJ. A review of the technical specifications of 47 models of diving decompression computer. *Underwater Technology*. 2010;29:63-72.
3 Sayer MDJ, Wilson CM, Laden G, Lonsdale P. The consequences of misinterpreting dive computers; three case studies. *Diving Hyperb Med*. 2008;38:33-9.
4 Azzopardi E, Sayer MDJ. Estimation of depth and temperature in 47 models of diving decompression computer. *Underwater Technology*. 2012; 31:3-12.
5 Sayer MDJ, Doolette DJ, Barrington J. Calculating the probability of decompression sickness: comparative analysis of dive computer profiles. *Undersea Hyperb Med*. 2005;32:301-2.
6 Sayer MDJ, Cook EJ, Wilson CM, Barrington J. Analysing dive computer profile integrations from incidents of suspected and actual decompression illness using cumulative nitrogen loading. *SPUMS Journal*. 2005;35:59-66.

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