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The Evolution of

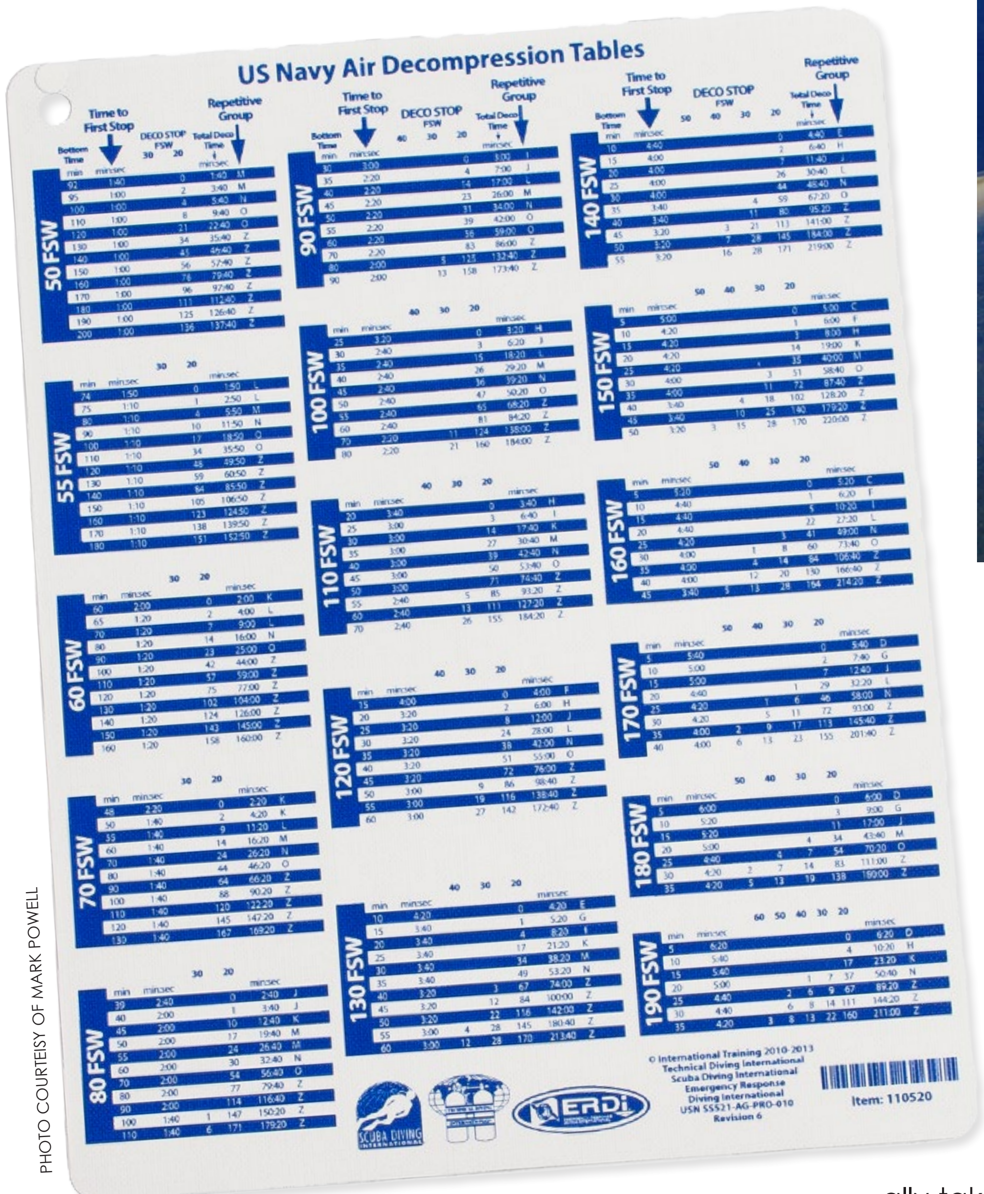
Dive Planning

Text by Mark Powell

"Plan the dive and dive the plan" has long been the mantra employed in all areas of diving. Technical divers in particular spend more time planning their dives than many recreational divers. This is due to a number of factors, including increased risks, greater depths, high gas usage at depth, increased decompression obligations, increased oxygen toxicity loading and a host of other reasons. For many recreational divers, dive planning has become a lost art, but technical divers still place a large emphasis on the value of dive planning. Despite this, the methods of dive planning have changed to take advantage of changes in technology and equipment. In this article, we will look at how dive planning for technical divers has evolved and how we can best make use of modern technology while still maintaining safety.

In the early days of technical diving, there were no PC planning tools or dive computers suitable for technical dive planning. The only option for planning a dive was to look up a decompression schedule using pre-generated tables. Initially, not even the pre-generated tables were publicly available, and the very earliest technical divers had to use commercial diving tables or work directly with decompression researchers if they wanted to obtain a set of trimix tables. The decompression schedule would be copied out on a dive slate with fixed decompression stops and run times. Central nervous system (CNS) and oxy-

Pre-printed decompression tables (below)



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gen toxicity units (OTU) loading would be calculated by hand. Gas usage would be calculated for each phase of the dive and the rule of thirds was used to add in a safety reserve. The dive would then be executed by following the dive plan run times written on the slate, with depth and time being monitored using a bottom timer.

Backup plans would also be prepared just in case the diver goes slightly deeper, stays slightly longer or, in the worst case, goes both deeper and stays longer. With pre-prepared decompression tables, "slightly deeper" was usually taken to mean the next depth increment, which on many tables was 3m or 10ft deeper. "Slightly longer" would be taken to mean anything from three to five minutes longer. Finally, a backup plan would also be prepared showing the decompression schedule if the divers lose their decompression gas and have to complete their decompression using back gas.

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Using a PC planning tool to generate a dive plan (left)

Personal computers

With the increased availability of personal computers, it became feasible to generate custom tables using a PC planning tool. This allowed divers to use a number of different gasses, decompression models and conservatism settings. The overall process of planning a dive remained the same, just using a planning tool instead of tables. The planning tool would generate the decompression schedule, CNS and OTU loadings as well as gas requirements. The only difference would be that the PC planning tool would do the laborious arithmetic required to calculate gas requirement, CNS loading, etc. rather than the diver doing it by hand. When used correctly, these PC planning tools removed the risk of the diver making a silly arithmetical error. The computer-generated schedule would then be transferred to a slate just as when the plan is generated by hand. In the water, the dive would be executed in exactly the same way, with divers using their bottom timers to monitor the run times written on the slate.

In time, personal dive computers became available that could handle decompression diving, trimix or rebreathers, but they were still expensive and often unreliable. As a result, it was common to use a written plan on a slate with a computer as backup, in case of going off the plan or in case of an emergency.

This was not an ideal situation as divers would have to spend a significant amount of money on a dive computer without being able to make full use of it. This led to the difficult situation in which divers would have to forego the flexibility offered by the dive computer and stick to a fixed depth and time in order to be able to fall back on their written backup plans in the case of a computer failure. This difficult decision made many divers and agencies question the suitability of dive computers for technical diving.

However, as computers become more common, reliable and affordable, this gradually changed. Divers would still use a planning tool to generate a decompression schedule to write on their slate just as before. The change was that this schedule was now used as a backup to the computer, which became the primary method of running the dive. Despite this, the plan would still primarily be predetermined in terms of a fixed bottom time, in order to still be able to fall back on the written plan. However, the actual ascent time would now be determined by the deco schedule on the computer.

Now computers are much more avail-

Using slates and wetnotes for dive plans (above); Technical diver with a rebreather (top right)

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able and reliable. In addition, the costs have reduced so much that many people have backup computers. The flexibility offered by the computer is in contrast to the rigid nature of tables. Unfortunately, when your backup is based on written tables you cannot make full use of this flexibility. However, when you have a backup computer, suddenly this flexibility comes into its own, and this is where significant changes to planning styles started to be adopted.

Significant changes

When you have a fixed decompression schedule, working out the gas usage for that schedule is very straightforward. The disadvantage of having flexibility in the decompression schedule is it now becomes impossible to calculate exactly how much will be required in advance.

This is where a shift in the approach is required. Let's consider the point of gas planning: It is to ensure we do not run out of gas, even in an emergency situation. Specifically, we want enough gas to get ourselves and our buddy to the surface, or to the next breathable gas source, even in a stressful situation. This is known as minimum gas.

We can calculate our minimum gas in advance for our maximum planned depth. This is based on combining the breathing rates of our buddy and ourselves and then doubling this figure to take into account the stress of an out-of-air emergency. This is then multiplied by the time it will take to start the ascent and ascend to the first gas switch stop.

We can then multiply this by a figure to account for the increased pressure at depth to give us the total volume of gas required in litres. Finally, we can then convert this into a bar pressure by dividing by the size of your cylinders.

Let's say that after performing this calculation, we know that our minimum gas is 70 bar. This means that at any point in the dive, as long as I have at least 70 bar, I know I have enough gas to get to the next source of breathable gas, even if my buddy has a catastrophic gas loss. Once one of us reaches 70 bar, we must then start the ascent. Using minimum gas rather than fixed usage gives us the flexibility in back gas planning to match the flexibility in decompression schedules provided by the dive computer.

Decompression stops

Minimum gas calculations will cover the gas required to get to the first gas switch, but what about the gas required for the

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decompression stops? The traditional approach has been to work out exactly what is required and see how much is available, and ensure that the amount required, plus a contingency, is less than the amount available.

The alternative is to use a planning tool to find the maximum amount of decompression that can be done on the gas available, without exceeding the safety reserve. You now know that you can do this amount of decompression, and this can be converted to a total time to surface. Again, you know that this time to surface can be done within the gas available. This means that as long as the total time to surface is less than this maximum amount, you know you have enough gas available.

Putting these two concepts together, the procedure is to first calculate the longest dive that can be done at the target depth within the decompression gas limits. This can be used to find the maximum time to surface (TTS). We then calculate the minimum gas required to get divers and their buddies up to their first gas switch. Provided the dive is around the target depth, the divers just need to monitor their available gas and their time to surface. The actual bottom time becomes less important. The dive is terminated when either of these limits is reached: either the available gas reaches the minimum gas limits, or the total TTS reaches the maximum amount.

If one dives with a regular buddy and always use the same size cylinders and the same gas mixtures, then this means that the minimum gas and time to surface will always be the same for each dive at that depth. As a result,

Depth (m)	Minimum Gas	Time to Surface (TTS)
45	70	62 minutes
50	75	64 minutes
55	80	67 minutes
60	85	72 minutes

Sample dive planning table showing minimum gas and TTS for a range of depths. Note these are not real numbers and should not be used for dive planning.

Dive Planning

For decompression stops, the traditional approach has been to work out exactly what is required and see how much is available, and ensure that the amount required, plus a contingency, is less than the amount available. The alternative is to use a planning tool to find the maximum amount of decompression that can be done on the gas available, without exceeding the safety reserve.

you only need to calculate these numbers once for any given dive depth. With a PC planning tool, it is very easy to calculate these two numbers for a range of dive depths. This can be turned into a table in your wet notes that then contains all the required information you need for dive planning.

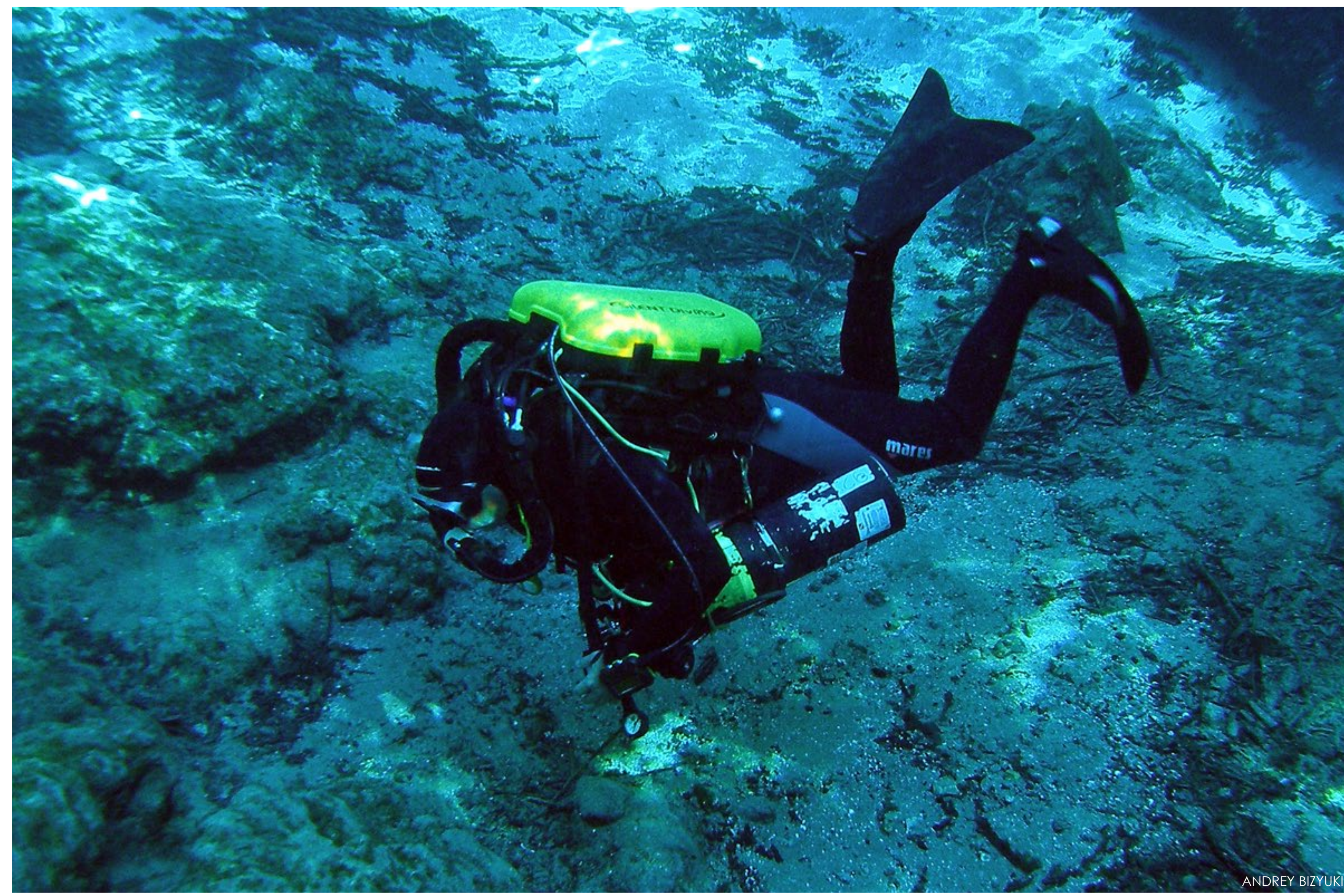
For most dives, it will be gas usage, either backgas, deco gas or, in the case of CCR, bailout gas, that will determine the limits of the time. Other factors such as CNS should also be considered, but when the dive plan is generated using the PC planning tool, the CNS can be reviewed and, provided it is well within safe limits, can be considered as a secondary consideration to the real limiting factor.

Rebreathers

The discussion above has mainly been concerned with open circuit diving, but CCR diving has progressed along a similar path. Modern rebreathers almost always have a built-in decompression computer integrated into the handset, and most divers have a backup computer.

However, gas planning is very different on a rebreather, compared to open circuit. A CCR has almost unlimited gas and, if nothing goes wrong with the CCR, it is likely to be scrubber duration or CNS limits that will determine the maximum length of the dive. The only time that gas usage becomes an issue is in the case of a bailout where gas availability becomes critical.

In reality, it is the bailout scenario that will normally be the limiting factor for most CCR dives. This means that bailout planning will determine the limits for TTS. This is done by using a planning tool to calculate the maximum CCR bottom time that can be done without then exceeding the available bailout gas, when the diver bails out at the end of the planned CCR bottom time. The CCR TTS at this point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Technical diver with a rebreather

Author and technical diving instructor Mark Powell ready for a dive.

becomes the end point of this dive, as we know that as long as we stay within this CCR TTS, the corresponding bailout ascent is achievable with the bailout available.

Overhead environments

Overhead environment diving also introduces a number of other factors. For cave and wreck penetration, the minimum gas and time to surface calculations will have to include the time required to exit the overhead environment as well as the time to ascend, and so the planning becomes more complicated.

For more advanced dives, when the depths are greater than 80m, more planning factors come into play. Team logistics become the more important factor and, although time to surface and minimum gas calculations can still be used, there are a whole range of additional factors, such as the use of support divers, surface support emergency planning.

Technical training tends to follow the evolution above with new divers starting with written plans, generated from pre-printed tables or PC planning tools. This ensures that the diver understands the principles behind decompression schedules and gas planning. It also ensures that the diver can manage ascent rates and display the discipline required to follow the dive plan on the computer accurately. The diver then moves on to using dive computers with tables on a slate as a backup before eventually planning by using the TTS and minimum gas approach.

Using TTS or minimum gas does not remove the need for planning. You still need to do the planning in order to know your minimum gas or TTS, but the details of the decompression profile can be calculated "on the fly" by the dive computer. By understanding the minimum gas and time to surface concepts, the combination of dive planning using a PC planning computer and the use of a dive computer to intelligently manage the execution of the dive provides the best of both worlds. The dive is still planned to ensure more than adequate safety. Divers still have to understand the details of their dive plans and should not "blindly" follow their dive computers. But at the same time, they can make use of the flexibility offered by modern dive computers. ■

Mark Powell is one of the leading technical diving instructors in the field. He has been diving since 1987 and instructing since 1994, and is a full-time technical diving instructor trainer and a member of TDI's Global Training Advisor Panel. He teaches all levels up to and including Advanced Trimix Instructor. In addition, he has led a number of expeditions to various parts of the world, including the Middle East, Costa Rica, Malta and the Red Sea, but is usually found diving the wrecks around the coast of the United Kingdom. For more information on any aspect of technical diving, visit: ***Dive-tech.co.uk****.*