TEC DEEP DIVER

Manual

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DSAT

DIVING SCIENCE AND TECHNOLOGY

Student Diver

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Tec Deep Diver Manual

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Dedicated to the memory of

I. Sheck Exley, 1949-1994

explorer, cave diver and teacher.

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From that first moment underwater, I knew that every spare hour I could squeeze away from mundane duties would be spent submerged. My greatest regret was that the demands of my career left too little time for diving.

— **Lloyd Bridges**
Star of the 1950s television series, *Seahunt.*

INTRODUCTION

At forty five metres — one hundred fifty feet — deeper than most recreational scuba divers ever go — you reach the wreck of a merchant ship few will ever see. Gloves guard your hands, but you grip carefully amid the torn, outward splayed sheet metal of her mortal wound. At your touch, from somewhere deep in your psyche, you feel the explosion that killed this ship. You *hear* it echo through the decades, reverberating in the official reports and the black-and-white films. Past becomes present and history lives as you feel the steel that once cut the waves in the name of commerce.

No book, no picture nor story can do this — only *being there*. And that's when you decide that everything it took to get you there — the years of experience, the weeks of training, the hours of planning, the money and the risk — was worth it.

Twenty five minutes fly by. Time to go. You look to your team mates, already giving thumbs up. Together you head up. Above, the surface is far, far away. Your computer tells you that this dive will cost more than hour in hang time, though you'll reduce that a bit when you switch gases at 9 metres/30 feet.

This is the type of dive that tec diving — technical deep diving — is all about. It takes you to sites and experiences beyond recreational diving, but for a price. Technical deep diving is more hazardous, and the only way to manage the hazards is through extensive equipment and the extensive training you need to use it. It requires you to commit to gaining the prerequisite skills and experience, to hours practicing and mastering new skills, and then to applying what you've learned strictly, without exception or compromise. Even then, technical deep diving carries more risk than recreational diving — and you must be willing to accept this risk.

Technical diving is not for everyone. It is not necessary to be a tec diver to enjoy diving, nor should you think of it as an inevitable step in a diver's growth. You can enjoy diving for decades without ever making a tec dive. But, if you find you're interested in it, the DSAT Tec Deep Diver course is the start, introducing you to the first step in technical deep diving.

Through the Tec Deep Diver course you'll learn the rudimentary skills for diving deeper than 40 metres/130 feet, making dives with planned staged decompression, and for using multiple gas blends on a single dive. You'll find it one of the most intensive and extensive courses you've taken; anything less than your full, serious commitment will not be enough. But, if this type of diving appeals to you, if you're willing to accept the risks, responsibilities and obligations, and if you invest the effort and money required, you'll find it one of the most rewarding experiences you'll have in diving.

How to Use the DSAT Tec Deep Diver Manual

The DSAT *Tec Deep Diver Manual* guides you through the DSAT Tec Deep Diver and/or Apprentice Tec Diver course (s). You'll use it as both your primary knowledge development learning tool for the course, and a reference you'll need for planning technical deep dives long after you finish the course.

During the course, you'll read each assigned section before meeting with your instructor to go over and apply what you're learning. Tec diving mandates *extensive* foundational knowledge; **it's crucial that you complete your study assignments on time as assigned, or you'll find it difficult or impossible to progress through the course.** Furthermore, **what you study has tremendous bearing on your safety.** This is no place to try to cut corners. **It won't work and you could get hurt, or worse.**

Begin each study assignment by glancing through the chapter and noting the subheads, topics and pictures. This gives you an idea of what you'll be studying and how it fits together, providing the beginning of a mental "framework" upon which to build. Begin reading, starting with the Tec Objectives as you progress through each section. Tec Objectives appear as questions that you need to be able to answer; look for the answers as you read. Underline or highlight these as you find them — actually writing (not just mentally noting) will help you when you review for the Exams, plus speeds learning.

You'll find Tec Exercises throughout each chapter. The Exercises have two purposes: first, they allow you to gauge your learning. If you have difficulty with Exercise questions, you can reread the section until you understand. This avoids trying to move on with incomplete knowledge, which only hinders further learning.

It's important that you *actually* write or *mark the answers* because the Exercises' second purpose is to help you transfer what you're studying from short term to long term memory. As with actually underlining/highlighting, writing the answers – not just thinking them – enhances learning speed and retention.

At the end of each chapter you'll find a Knowledge Review. Complete the Knowledge Review, going back to reread material if you have difficulties as necessary. Remove the Knowledge Reviews from the manual to hand in to your instructor. Your instructor uses the reviews to assure that you're studying, to gauge your progress, and to tailor presentations to the specific learning needs of you and your fellow students.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the goals of the Tec Deep Diver and Apprentice Tec courses?
2. What are your obligations and responsibilities in taking these courses?
3. What are the consequences of failing to meet these obligations and responsibilities?

Tec Deep Diver and Apprentice Tec Diver Course Overview

The DSAT Tec Deep Diver course consists of six Knowledge Development sections (including two exams), eight Practical Applications and twelve Training Dives sequenced so that you develop new knowledge and skills, building more complex abilities upon prerequisite, foundational abilities. For this reason, your instructor will require you to successfully complete each Knowledge Development section prior to the following Practical Application, and each Practical Application before the Training Dives that follow it. (Note: The exception is Training Dive One, which may precede its Knowledge Development and Practical Application.)

Tec Deep Diver Course Goals

The Tec Deep Diver course is the primary course for technical deep diving beyond recreational diving. The DSAT Tec Deep Diver course has five primary goals:

- To qualify you to make gas switch, extended no decompression dives, decompression stop dives and accelerated decompression dives using air, enriched air and oxygen to 50 metres/165 feet, using technical diving equipment and procedures required to manage the risks involved.
- To train you in the motor skills required for technical scuba diving.
- To assure you understand and acknowledge the hazards and risks involved with the above types of technical diving, as well as the limits to training received in the course.
- To train you to prepare for and to respond to reasonably foreseeable emergencies that may occur in this type of technical diving.
- To provide the foundational skills for further training in technical diving.

Prior to enrolling in the Tec Deep Diver course, you will need to verify that you meet these prerequisites:

1. Certified as a PADI Advanced Open Water Diver or equivalent.
2. Certified as a PADI Rescue Diver or equivalent.
3. Minimum age: 18 years.

Tec Diver Lingo

When you start hanging around with tec divers, you'll start hearing terms not common in recreational diving. So, here are a few to get you learning the lingo.

algorithm Particular version of a decompression model

back gas The gas in your doubles; usually the lowest oxygen blend you have, used on the deepest part of the dive.

blow a bag Send up a lift bag.

blow up Lose buoyancy control and ascend out of control, esp. in a dry suit.

bust a stop Skip a required decompression stop, due to error or emergency.

CNS hit A convulsion caused by oxygen toxicity to the central nervous system.

deco Short for "decompression;" as in "That calls for six deco stops," "That was a short deco," or "What deco tables are you using?"

DCI/DCS hit To suffer DCI/DCS.

gas Generic term for breathing gases, including any blend of enriched air, or air, or oxygen.

hang Decompression stop or stops, as in "How long was the hang?" Comes from hanging on to an anchor or mooring line while decompressing.

Hogarthian A slang term for the most common, standard tec rig layout.

hyperoxic gas A gas blend with more than 21percent oxygen.

hypoxic gas A gas blend with less than 21 percent oxygen.

jon line Short line used to clip you to the anchor line while decompressing in a current.

kit Your set up gear; scuba unit.

long hose The primary second stage on an approximately 2.2 metre/7 foot hose that you breathe from, and pass to a team mate in an emergency.

MOD Maximum Operating Depth — the maximum acceptable depth at which you can breathe a gas (based on oxygen partial pressure). With "operating" superfluous, many divers just use "Maximum Depth" interchangeably with "MOD."

normoxic gas Air or other gas blend with 21percent oxygen.

O_2 (oh-two) oxygen, or 100% oxygen

software Computer software used for creating custom dive tables.

stage To leave something to retrieve later, especially a stage bottle or decompression cylinder. Sometimes used as short for "stage bottle."

suicide clip Clip with a swinging gate, such as a marine clip, so called because they latch to things by themselves, sometimes posing an entanglement hazard.

tec, tek, tech Short for "technical" as in "tec diving gear" or "she's a tec diver."

thirds Most common reserve in tec diving — saving one third of gas for emergencies.

tox To suffer oxygen toxicity; often a reference to a CNS convulsion.

turn pressure Pressure at which you end the dive, or turn toward the exit, so that you end with the required reserve.

wings Tec diving BCD bladders; also brand name of a BCD.

4. Certified as a PADI Enriched Air Diver or equivalent.
5. Certified as a PADI Deep Diver or equivalent.
6. Have a minimum of 100 logged dives, of which at least 20 dives were made with enriched air nitrox, 25 dives were deeper than 18 metres/60 feet and at least 15 dives were deeper than 30 metres/100 feet.

Certification as a DSAT Tec Deep Diver means you're qualified to plan and make decompression stop dives and extended no stop dives, using air, enriched air and oxygen, to a maximum depth of 50 metres/165 feet in conditions comparable to, or better than, those in which you've been trained and have experience.

Certification as a DSAT Tec Deep Diver means you're qualified to plan and make decompression stop dives and extended no stop dives, using air, enriched air and oxygen, to a maximum depth of 50 metres/165 feet in conditions comparable to, or better than, those in which you've been trained and have experience. You'll also be qualified to purchase or rent air, enriched air and pure oxygen, and equipment required for those gas blends.

Apprentice Tec Diver Course Goals

The Apprentice Tec Diver course addresses those divers with a clear interest in and motivation to pursue tec diving, but who still lack the prerequisite experience and training required to fully enter tec diving. The Apprentice Tec Diver course is a subcourse within the Tec Deep Diver course (first four Knowledge Development sections, four Practical Applications, and seven Training Dives) and uses Tec Deep Diver course materials, including this manual. The goals of the Apprentice Tec Diver course are:

- To qualify you to make gas switch, extended no decompression dives to 40 metres/130 feet using air, enriched air with up to 60 percent oxygen, using technical diving equipment and procedures.
- To train you in the motor skills required for technical diving.
- To assure you understand and acknowledge the hazards and risks involved with technical diving, as well as the limits to the training received in the course.
- To train you to prepare for and respond to reasonably foreseeable emergencies that may occur in this type of diving.
- To provide the foundational skills and knowledge for completing the entire Tec Deep Diver course.

Prior to enrolling in the Apprentice Tec Diver course, you need to verify that you meet these prerequisites:

1. Certified as a PADI Advanced Open Water Diver or equivalent.
2. Minimum age: 18 years.
3. Certified as PADI Enriched Air Diver or equivalent.
4. Certified as a PADI Deep Diver or equivalent.
5. Have a minimum of 50 logged dives, of which at least 10 dives were made with enriched air nitrox, 12 dives were deeper than 18 metres/60 feet and at least six dives were deeper than 30 metres/100 feet.

Your instructor may apply the portions of the Tec Deep Diver course that you complete in the Apprentice Tec Diver course toward the Tec Deep Diver course, which you may complete after meeting all the prerequisites.

Certification as a DSAT Apprentice Tec Diver means that you're qualified to plan and make no stop dives and extended no stop dives using air and enriched air (up to 60 percent oxygen) to a maximum depth of 40 metres/130 feet, in conditions comparable to, or better than those in which you've been trained and have experience.

Certification as a DSAT Apprentice Tec Diver means that you're qualified to plan and make no stop dives and extended no stop dives using air and enriched air (up to 60 percent oxygen) to a maximum depth of 40 metres/130 feet, in conditions comparable to, or better than those in which you've been trained and have experience. You're also qualified to purchase or rent air and enriched air (up to 60 percent oxygen) equipment.

Your Obligations and Responsibilities

Beyond the listed prerequisites, your instructor accepted you into the Tec Deep Diver or Apprentice Tec Diver course believing that you have the attitude as well as the *aptitude* to pursue technical diving (your instructor has no obligation to accept all students who apply, even if they meet the prerequisites, provided the basis for refusal doesn't go against any antidiscrimination laws, of course). Your instructor recognizes that tec diving and training for it impose significant demands; rising to these challenges begins with you acknowledging and accepting your responsibilities in this course. You agree to:

- Follow the instructor's directions and dive plans strictly, and to not separate from the instructor or your dive team.

- Refrain from tec diving outside this course until you're fully qualified and certified.
- Maintain adequate physical and mental health, and to alert the instructor to any problems you have with them.
- Accept the risk for this type of diving, and for specific risks unique to each dive environment, and to immediately notify the instructor if this risk becomes intolerable for you.

Failing to meet these obligations and responsibilities can have unfortunate consequences. In the worst case, you could be injured, disabled or killed. Even if you avoid these, you will have failed to demonstrate the attitude and maturity required for tec diving, and your instructor may, in the interests of safety, have you discontinue the program. In any case, you will not qualify for certification.

Diver Accident Insurance

Diver accident insurance that covers tec diving, such as the PADI Platinum Diver Protection program (or equivalent), is just too inexpensive not to have. Although the possibility of a decompression-related accident is low, it is still higher than in recreational diving. Recompression can have extensive medical costs that your normal medical insurance may not cover at all, or not cover entirely.

For this reason, having coverage by the PADI Platinum Diver Protection program, or a similar program, is *highly recommended* if it's available in your area. **Your instructor may require it.**

Tec Exercise – 1.1

1. The goals of the Tec Deep Diver course include (check all that apply):
   - ☐ a. qualifying you to make gas switch no decompression dives.
   - ☐ b. qualifying you to make decompression dives as deep as 55 metres/180 feet.
   - ☐ c. assuring you understand the hazards and risks of technical deep diving.
   - ☐ d. providing the foundation for further training in tec diving.
2. The goals of the Apprentice Tec Diver course include:
   - ☐ a. qualifying you to make gas switch no decompression dives.
   - ☐ b. qualifying you to make decompression dives as deep as 50 metres/165 feet.
   - ☐ c. assuring you understand the hazards and risks of technical deep diving.
   - ☐ d. providing the foundation for further training in tec diving.
3. Your obligations and responsibilities as a student in the Tec Deep Diver or Apprentice Tec Diver course include agreeing to follow the instructor's ________________ and _________ __________ strictly, and to not _________________ from the instructor or your dive team.
4. Failure to meet your obligations and responsibilities can (check all that apply):
   - ☐ a. lead to injury, disability or death.
   - ☐ b. make it necessary for you to discontinue the course.
   - ☐ c. make it inappropriate for you to qualify for certification.

Check it out.
1. a, c, d. (b is incorrect — the course qualifies you to 50 metres/165 feet). 2. a, c, d. (b is incorrect — the Apprentice Tec Diver course does not qualify you to make decompression dives). 3. directions, dive plans, separate 4. a,b,c.

ONE

If you can't take a little bloody nose, maybe you should go back home and crawl under your bed. It's not safe out here. It's wonderous, with treasures to satiate desires both subtle and gross. But it's not for the timid.

— **Q**, on exploring deep space, *Star Trek - The Next Generation*

Chapter ONE: The Foundation

This is a long chapter, though you'll find it has the three qualities preferred by students in all fields the world over: wide margins, large type and lots of pictures. But the reason for a long chapter is that technical deep diving requires that you develop several new, broad sets of knowledge and skills. Chapter One establishes your learning base — the fundamentals behind *everything* you'll apply and build upon through all the Knowledge Development sessions, Practical Applications and Training Dives.

To establish the wide learning base you need for the Tec Deep Diver and Apprentice Tec Diver courses, Chapter One plunges you into several topics, most of which you'll pick up and further in subsequent chapters. You start by going over the *risks and responsibilities* you have as a tec diver and a member of the technical diving community — that is, what you're getting yourself into. Most student divers really love the next topic, tec diving equipment: what you need, why and how you rig it all together. It's really hands on, and you might want to have your gear at hand while you read.

The **Tec Deep Diver Manual** *establishes the principles you'll need as you learn, practice and apply tec diving procedures underwater.*

After that, you'll get into gas planning, which is a broad topic that covers what gases to use, reserves, oxygen toxicity, dive tables and computers and more. Gas planning is fundamental to tec diving, so pay close attention. *Team diving* shows you how to work with others for successful tec diving; think of it as the buddy system on steroids.

Techniques and procedures gets you back into your gear, underwater this time, and gives the basics on the skills you'll be practicing and applying during your training dives. *Emergency procedures* does the same, only specific to handling problems while tec diving. This leads into *thinking like a tec diver*, which helps you shape your attitudes and approach to technical diving. This takes you beyond the how-and-what of tec diving into the mind set that has proved successful again and again for the world's leading tec divers.

Finally, you'll get an overview of what you'll be doing as you put what you learn here into practice during the first practical application and training dive.

The Birth of Tec Diving

Modern technical diving is a relative newcomer in diving, largely emerging in the early 1990s as a distinct form of underwater exploration, but with its origins dating well back to cave diving in the 1960s.

Tec diving apparently grew out of several diver groups who were pushing and exceeding the limits of recreational diving. Cave diving had been the mainstay of tec diving since the late 1960s, but by the mid1980s wreck divers on both sides of the North Atlantic were plunging well past the 40 metre/130 foot limit. Other cave divers – particularly in the 1988 Wakulla Project – were making use of enriched air nitrox and other gas blends to extend their depths and durations as they explored farther and farther into underwater caves. All of these groups were quietly laying the groundwork and establishing new technologies and methodologies.

It was the publication of aquaCorps magazine that brought technical diving "out of the closet" and allowed it to emerge as the distinct, somewhat extreme activity for a minority of highly visible, but dedicated divers. Frustrated by mainstream diver magazines that refused to run articles about the pioneers pushing beyond recreational diving limits, writer Michael Menduno founded aquaCorps, simultaneously coining the term "technical diving." aquaCorps immediately picked up a following and grew, soon spawning its associated Tek Conference. Quickly it became evident that there were many small groups of dedicated divers around the world pioneering technical diving.

aquaCorps and the Tek Conference no longer exist, but it was through them that tec diving as we know it came to be.

Technical Diving's Risks and Responsibilities

Technical and Recreational Diving

"What's technical diving? How does it differ from recreational diving?"

If you're considering getting into it, those are not only fair questions but ones likely to get different answers depending upon who you ask and how confused you want to get. Some people get caught up in whether you're diving for fun, or for work, or for what — which only muddies the issues. If you're an instructor getting paid, is it still "recreational"? Maybe that's commercial or professional. Maybe not. See why this approach gets awkward?

We'll define technical and recreational diving based on limits and methodologies and skip whether you do either for fun, to teach, to make your spouse happy or whatever.

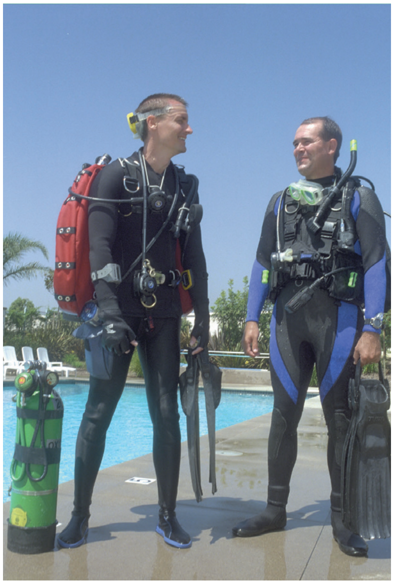
Recreational scuba diving is defined as no stop diving with air or enriched air to a maximum depth of 40 metres/130 feet, and during penetration dives, within the natural light zone and no more than a total linear distance of 40 metres/130 feet from the surface. Typically, this means using relatively simple equipment (e.g., single tank and regulator), immediate access to the surface in an emergency and less complex training requirements. Thanks to its relative simplicity, it's open to diverse physical and mental characteristics, making it an appropriate activity to a very broad range of people.

Technical scuba diving is diving other than conventional commercial or research diving that takes divers beyond recreational diving limits. It is further defined as and includes one or more of the following: diving beyond 40 metres/130 feet, required stage decompression, diving in an overhead environment beyond 40 linear metres/130 feet of the surface, accelerated decompression, and/or the use of variable gas mixtures during the dive. Technical scuba diving uses extensive methodologies, technologies and training to manage the added risk. Typically

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. How do you define recreational scuba diving and technical scuba diving?
2. What is not technical diving?
3. What six general risks and hazards does technical diving present that either don't exist, or aren't as severe, in recreational diving?
4. Why does technical diving, even done "by the book," pose more risk to you than recreational diving?
5. With respect to risk, what single statement sums up the difference between recreational diving and technical diving?
6. What are the limits of your training as a DSAT Tec Deep Diver or a DSAT Apprentice Tec Diver?
7. What risks do you face if you exceed the limits of your training and experience?
8. How could a lack of physical fitness affect you as a technical diver?
9. What are six characteristics of a responsible technical diver?
10. What should you do if you can't or won't accept the risks and responsibilities demanded by technical diving?



Technical divers (left) compared to recreational divers (right) use more extensive technologies and methodologies to manage the added risk of exceeding recreational limits.

this means using complex equipment in situations where direct access to the surface is inaccessible due to a ceiling imposed by decompression, or other physical barrier such as that found in a cave or a wreck diving environment. It calls for comparatively complex and extensive training requirements, with physical and mental characteristic demands that limit technical diving to a narrower population. In technical diving relatively short error chains move readily to an accident (that is, a single error or only a couple of linked errors lead to an accident).

Obviously, tec diving has a more open-ended definition than recreational diving, meaning that you can classify many different types of diving as technical diving. However, simply exceeding recreational limits is not tec diving. A diver can't justify going to 50 metres/165 feet in the identical kit a recreational diver uses at 18 metres/60 feet by calling it technical diving. The only thing you call it is stupid.

Technical Diving Hazards

Already you've read several times that tec diving is more hazardous than recreational diving. Tec diving is rewarding, and presents challenges and opportunities few other activities offer, but it's not without risks. Many tec diving risks either don't exist in recreational diving, or are more severe than in recreational diving. These include, but aren't limited to:

1. Lack of direct or immediate access to the surface in an emergency due to decompression requirements, distance or both.

2. Hypoxia or hyperoxia, both of which can lead to unresponsiveness and drowning. Hypoxia or hyperoxia can result from switching to the wrong gas, improper gas choice, or failing to properly analyze your gas.

3. Narcosis, which can lead to poor judgment or bad decisions that cause an accident, or slowed responses to emergencies that cause you to fail to adequately handle an accident.

4. DCS with severe permanent injury, or death. This can result from higher nitrogen/inert gas loading, improper gas analysis, loss of decompression gas, being forced to surface without completing decompression, improper decompression calculation, personal pre-

disposing factors, diving outside the envelope of well documented decompression theory, and other causes.

5. Omitted procedures and errors caused by task overloading, leading to accidents from DCS, gas loss, runaway ascents leading to arterial gas embolism, or barotrauma or oxygen toxicity caused by runaway descents, etc. The need for extensive redundant equipment configurations also contributes to task loading due to ergonomic complexity and physical burden.

6. Drowning due to failed BCD and back up buoyancy control while diving heavily weighted with equipment. It is also possible to drown in heavy gear due to entering the water with all your cylinder valves closed (due to an improper predive check) and sink, unable to inflate your BCD or breathe.

Tec diving has several risks that you don't have in recreational diving, including a lack of direct or immediate access to the surface in an emergency, due to decompression requirements, distance or both.

Most of what you learn in the Tec Deep Diver and Apprentice Tec Diver courses deals with avoiding problems and with what to do if they occur. Still, even when you do everything "by the book," tec diving poses more risk than recreational diving because there are more variables, more potential hazards, the error chain leading to an accident is short, and surfacing in an emergency is (usually) not an option.

To compare recreational diving to technical diving: In recreational diving, when you do everything properly to the best of your ability, the probability of a serious accident is very remote. In technical diving, with short error chains and surfacing generally not an option, this isn't true.

In fact, you can sum up the difference between recreational and technical diving in this statement: *In technical diving, even if you do everything right, there is still a higher inherent potential for an accident leading to permanent injury and death.* **You must accept this risk when you enter into technical diving and technical diver training.**

But let's not be overly dramatic. The vast majority of tec diving accidents result, as in recreational diving, from failing to apply the proper procedures, failing to have the required equipment, or failing to have the prerequisite training and/or experience. So, if you stay within the limits of your equipment and training, and you follow the proper procedures you learn, the probability of an accident isn't high — but it is there, and higher than in recreational diving. And, as stated before, if you have an accident, the consequences may be worse than a similar accident in recreational diving.

You can sum up the difference between recreational and technical diving in this statement: In technical diving, even if you do everything right, there is still a higher inherent potential for an accident leading to permanent injury and death. You must accept this risk when you enter into technical diving and technical diver training.

Let's look at the training limits of the DSAT Tec Deep Diver and Apprentice Tec Diver certifications.

Tec Deep Diver Certification Limits. As a certified DSAT Tec Deep Diver, you'll be qualified to:

- Dive to a maximum depth of 50 metres/165 feet using air or enriched air.
- Make decompression dives using air, enriched air or oxygen.
- Make extended no stop dives by switching gases during the dive.

Apprentice Tec Diver Certification Limits. As a certified DSAT Apprentice Tec Diver, you'll be qualified to:

- Dive to a maximum depth of 40 metres/130 feet using air or enriched air (max 60 percent oxygen).
- Make extended no stop dives by switching gases during the dive.

In both cases, the limits are based on using the required equipment and following the procedures you learn in this course, and on allowing for your experience or inexperience in the particular environment.

Risks from Exceeding Your Limits. Exceeding the limits of your training and experience poses some severe risks. Bluntly, you can suffer permanent injury, or death, due to an accident. Accidents caused by diving beyond limits usually arise because a) the diver fails to recognize a hazard, b) the diver doesn't know the procedure for preventing or handling a hazard or emergency, or c) the diver knows the procedure, but due to lack of practice either can't execute it, or executes it improperly.

Most divers who've had accidents when diving beyond their limits believed they knew how to handle the situation. Unfortunately, they were wrong. Some paid with their lives for this mistake.

Physical Fitness and Tec Diving. Hand in hand with your training and experience limits, you need to consider your physical limitations. Tec diving imposes higher physical demands on the diver than does recreational diving, particularly before and after the dive. These demands include wearing, standing in, boarding ladders or moving in substantially heavier gear. In hot weather, you may be exerting with this load while wearing a full dry suit or wet suit, imposing a high thermal stress. In the water, your gear adds significantly more drag, requiring more strength to speed up in an emergency, and more strength and endurance for a long swim. A long decompression, even in moderate water temperature with full exposure protection, can impose thermal stress due to chilling.

Physical fitness affects your performance and ability as a tec diver. Just as in recreational diving, you need to be confident that you have adequate physical resources for the dive you plan, plus sufficient reserve to deal with emergencies. Most tec dives call for higher fitness requirements than recreational dives. Lack of the physical fitness required can affect your safety by limiting your ability to respond to an emergency, or by directly leading to injuries such as a heart attack, heat exhaustion or stroke, broken bones or muscle tears due to falling or strain.

Physical fitness affects your performance and ability as a tec diver. Lack of the physical fitness required can affect your safety by limiting your ability to respond to an emergency, or by directly leading to injuries. You need sufficient skeletal and bone strength to carry the equipment – while wearing it and while loading, unloading and transporting it to and from the dive site. It's your responsibility to stay fit to dive, and to dive within the limits of your fitness.

Consider that your cardiovascular system needs to be able to tolerate thermal stress, plus support the muscle demand for oxygen while wearing and moving in heavy equipment out of water and while swimming at a moderate pace against the drag. You need sufficient skeletal and bone strength to carry the equipment — while wearing it and while loading, unloading and transporting it to and from the dive site. Only you and your physician can determine your fitness and assess its suitability for different types of diving. It's your responsibility to stay fit to dive, and to dive within the limits of your fitness.

The Responsible Tec Diver

The need to address the risks and hazards of tec diving has resulted in a philosophy reflected in the way the world's leading tec divers think and behave. (You'll be learning a bit more about this in the Thinking Like a Technical Diver sections of each chapter.) Despite tremendous cultural and personality differences, six characteristics seem to universally denote the responsible technical diver. As you go through the course, these are characteristics you want to learn, and adopt.

Technical diving has too little leeway for cutting corners, bending rules, disregarding dive plans, omitting safety equipment or exceeding the limits of your training and equipment. Responsible tec divers are methodical and uncompromising in everything from predive checks to post dive debriefings.

Self Sufficient. The responsible tec diver plans and executes each dive as though it'll be necessary to make the dive and handle all emergencies alone. That is, you should never rely on any other diver for the safety or knowledge required to execute a dive.

Team Player. Although self sufficient, the responsible tec diver dives as part of a team (not simply a buddy — more about this shortly). When you tec dive, you need to think of yourself as a team player contributing to a team effort.

Disciplined. Technical diving has too little leeway for cutting corners, bending rules, disregarding dive plans, omitting safety equipment or exceeding the limits of your training and equipment. Responsible tec divers maintain their self discipline, and so should you.

Wary. One of the best ways to come back from every technical dive is to assume that everything can and will go wrong, and then have contingency plans for when it does. Responsible tec divers are just a tad paranoid, and it serves them well.

Physically Fit. Responsible technical divers exercise regularly, eat properly, see their physician regularly and maintain the fitness level they need for the dives they make. You don't have to be an Olympian, but you do need to be fit for the dives you make, and as you just learned, that includes having sufficient physical reserve for emergencies.

Accepts Responsibility. To be a responsible technical diver, you need to accept responsibility for your personal safety, while accepting and acknowledging the risks and demands tec diving imposes.

If You Won't, Don't

After reading this section on technical diving's risks and responsibilities, you might think this manual's trying to talk you out of becoming a technical diver.

You bet!

The fact is, you can enjoy a *lifetime* of exciting, adventurous diving *without* ever making a decompression dive, without ever venturing deeper than 40 metres/130 feet and without ever penetrating a wreck or cave farther than that. Technical diving is not for everyone and it is *not* a goal for all divers to aspire to.

Therefore, if you can't or won't accept the responsibilities, risks and demands required by technical diving, then *don't do it*. All you'd be doing is endangering yourself and your fellow divers. Stop now. If you will accept them, on the other hand, then you're ready for the next step in your training.

Tec Exercise – 1.1

1. You define "technical diving" as diving beyond ____________ ___________ limits. It includes decompression stop diving and overhead environments, using ______________ ____________________ , __________________ and _____________ to manage the ____________ ___________.

2. Some forms of technical diving include making very deep (below 40 metres/130 feet), short dives using equipment no different from what you would use on a typical recreational dive.
   ☐ True ☐ False

3. General risks and hazards in tec diving that either don't exist or aren't as severe in recreational diving include (check all that apply):
   ☐ a. lack of direct/immediate access to surface
   ☐ b. exposure to marine predators
   ☐ c. DCS
   ☐ d. drowning due to failed BCD while diving heavily weighted with gear

4. Even when you do everything right, technical diving has more risk because there are more ___________ , more potential ____________ , the _____________ __________ leading to an accident is short, and __________ in an emergency is usually not an option.

5. In technical diving, even if you do everything _________, there is still a higher inherent potential for an ___________ leading to ___________ _______ and _______.

6. Certified Apprentice Tec Divers are qualified to make no stop dives with no stop time extended by switching gases during the dive.
   ☐ True ☐ False

7. Exceeding the limits of your experience and training in tec diving risks _____________ _________ or _____________.

8. Lack of the physical fitness required for a dive can affect your ___________ by limiting your ability to respond to a(n) ________________, or by directly leading to __________.

9. Characteristics of a responsible technical diver include (check all that apply):
   ☐ a. self sufficient ☐ c. wary
   ☐ b. disciplined ☐ d. accepts responsibility

10. If you can't or won't accept the risks and responsibilities of technical diving then ______ _____ ______.

Check it out:
1. recreational diving, extensive methodologies, technologies, training, added risk. 2. False. Tec diving employs more extensive equipment to manage risks. 3. a, c, d. b is incorrect because technical diving doesn't cause a substantial increased risk from marine animals. 4. variables, hazards, error chain, surfacing. 5. right, accident, permanent injury, death. 6. True. 7. permanent injury, death. 8. safety, emergency, injury. 9. a,b,c,d. 10. don't do it.

Equipment I – The Basic Technical Diving Rig

Scuba diving's a gear-intensive activity, but tec diving redefines "gear-intensive." In the diving world, snorkelers are gazelles, recreational divers are horses and technical divers are elephants. Tec diving requires a substantial investment in dive gear, but most tec divers have at least a bit of technophile in them, making the equipment part of the appeal.

Scuba diving's a gear-intensive activity, but tec diving redefines "gear-intensive." In the diving world, snorkelers are gazelles, recreational divers are horses and technical divers are elephants.

In recreational diving, you enjoy a good bit of latitude in how you arrange your gear. The demands of technical diving and working in teams, on the other hand, impose a need for higher standardization. For this reason, the rig you're about to learn has evolved in the technical

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is meant by "standardized technical rig," and why do technical divers need to apply it?
2. What guidelines apply to selecting masks, fins and snorkels for technical diving?
3. What characteristics should you look for in a cylinder valve or manifold used for deep technical diving?
4. What is the minimum number of fully independent regulators, per diver, and how do you configure each?
5. What three characteristics should you look for in a BCD, and what five characteristics should you look for in a harness, for a deep technical diving rig?
6. How do you choose an appropriate exposure suit for a deep technical dive, and how may your choice affect your BCD choice?
7. What are your options regarding a weight system, and what are the advantages and disadvantages of each?
8. What instrumentation do technical divers generally carry, and why do they generally avoid consoles?
9. What are the three types of computers you can use for technical deep diving with air and enriched air, and what are the advantages and disadvantages of each?
10. What types of cutting tools are appropriate for deep technical diving, and at least how many should you have with you?
11. What are six general guidelines regarding pockets, accessories and clips you might need when technical diving?
12. What are four recommendations regarding equipment maintenance?

You should also be able to:

13. Describe the layout, arrangement and configuration of the basic rig and equipment, head to toe, as worn for a technical deep dive.

community as the generally accepted basic tec diving setup. You still have some latitude to individualize your kit, of course — you're not being molded into a robot.

The best way to understand the basic rig is to first cover the philosophy behind it — why it is how it is — and then focus on each component and how it differs from the same component (if it does) in recreational diving. Then you'll look at how they all integrate into a surprisingly simple package that's the heart of being a lean, mean diving machine.

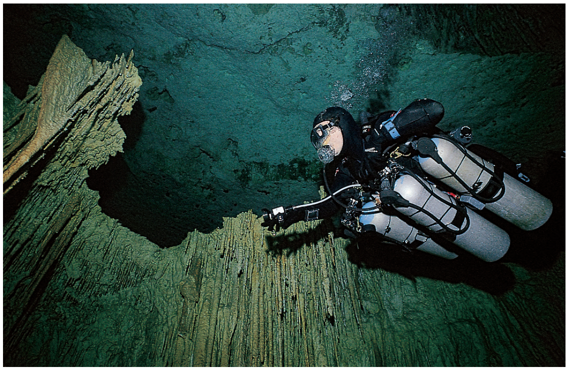
The Standardized Technical Rig

The most widely accepted technical rig springs from a gear layout and philosophy that originated with cave diving and slowly evolved into the "standard" way of doing things. The reason for the wide acceptance and emergence of this rigging mode as standard is because it follows a philosophy of streamlining and minimizing your gear so that nothing dangles, everything is accessible, and you eliminate the unnecessary. The current evolution emphasizes a diver/gear philosophy of "rig wreck, dive cave," which means you set your gear up for the most demanding environment (the deep wreck), but dive with the skill and finesse that typifies cave diving (efficient, no silt, complete buoyancy control mastery).

The standardized technical rig setup has become the most widely accepted basic tec rig layout for the simple reason that it works. It accommodates variations to meet the specific needs, yet maintains sufficient standardization to minimize task loading.

That may sound simple, but given the extensive equipment requirements of tec diving, it has been one of the challenges since its emergence. This is more than a convenience issue — you need to apply the standard technical rig philosophy to minimize confusion and procedural error due to equipment task loading. In an emergency, there's not a lot of time to figure out where your team mate's alternate second stage is. Streamlining is crucial to avoid entanglement and to conserve energy by minimizing drag. The standardized layout goes a long way to meeting these requirements.

The standardized technical rig setup you're about to learn has become the most widely accepted basic tec rig layout for the simple reason that it works. It accommodates variations to meet the specific needs you have as an individual and the varying demands of differing environments. It does this, yet maintains sufficient standardization to minimize routine equip-



Even highly specialized forms of technical diving, such as sidemount cave diving (tanks worn on the sides), tend to originate with the standardized rig.

ment handling and use as a major task load in the trained individual. Even highly specialized forms of technical diving, such as sidemount cave diving (tanks worn on the sides), tend to originate with the standardized rig.

Mask, Fins and Snorkel

Choose a mask that's compact to maximize streamlining and minimize having it jostled by current. It's also faster to equalize when descending quickly. Comfort is everything, especially considering you may be wearing it for two to three hours.

The mask strap should have retainers that keep the loose ends from dangling off your temples. Most decent quality scuba masks will do the job.

Choose a mask that's compact to maximize streamlining and minimize having it jostled by current. Comfort is everything, especially considering you may be wearing it for two to three hours.

For foot power, you need full-size power fins with sufficient blade area and flex. Most open heel, full size scuba fins meet the requirements; small full-foot fins typical of snorkeling and some tropical recreational diving won't cut it. Again, consider comfort — after pushing a full tec kit against a mild current for two hours, a minor pinch you put up with at the start turns into sheer torture by the end.

You need full-size power fins with sufficient blade area and flex, like these two well-worn sets. Many fins have strap retainers that keep the loose ends from flopping around (right). If not, you can often reverse them so the loose end routes to the inside or tape the loose ends with duct tape or electrical tape (left).

Many modern fins have strap retainers that keep the loose ends from flopping around. If not, you can often reverse them so the loose end routes to the inside (but check that the buckle still holds) or tape the loose ends with duct tape or electrical tape.

If you're one of those divers who finds a snorkel annoying, here's one thing you'll love about tec diving: you almost never wear a snorkel. While they're important standard equipment for recreational diving, in most tec diving circumstances they create drag and an entanglement hazard, with little real benefit.

You almost never wear a snorkel when tec diving. While they're important standard equipment for recreational diving, in most tec diving circumstances they create drag and an entanglement hazard, with little real benefit.

That being said, it would be wrong to say that they're never used in technical diving. In rare instances with long waits or swims at the surface in rough conditions, you might use a snorkel and then remove it, stashing it in your rig or leaving it on a float or handing it up to the boat, etc. So, the snorkel you have already probably does the job just fine because, chances are, you won't be using it. If you think conditions may call for it, you'll want a quick release snorkel keeper that lets you detach it easily without removing your mask.

Full face masks are not widely used for tec diving at this writing because they make it difficult to switch gas rapidly or use your team mate's long hose. However, at least one company is manufacturing a model with interchangable mouth "pods" that permit the diver to easily change gases and use standard second stages. The use of such a mask may be especially beneficial during decompression with oxygen because it may reduce drowning risk in the event of a convulsion. You may see these more commonly as they become available, and they may be the future trend in technical decompression diving.

KMS-48 © 2000 Kirby Morgan

The KMS-48 full face mask is a model with interchangable mouth "pods" that permit the diver to easily change gases and use standard second stages.

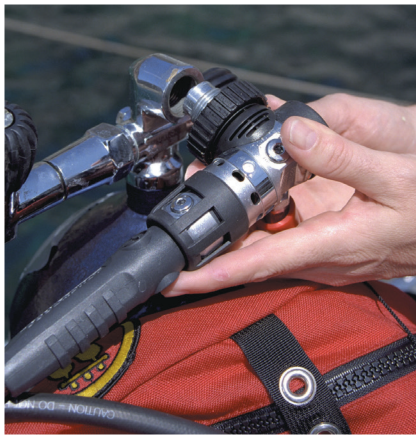
Cylinders and Valves

Most of the time, deep tec diving calls for twin cylinders that you choose based on your individual gas consumption, your size, and the dive requirements. In some instances a high capacity single cylinder, such as a 18-20 litres/105-120 cubic foot size, will suffice for a dive that's not too deep and has only a very short planned decompression, but most of the time you'll be in doubles. You may use a high capacity single cylinder for some of the training dives in Tec Deep Diver and Apprentice Tec Diver courses, but you will be using doubles most of the time, if not all.

The prime choice for a manifold is the DIN isolator manifold. The manifold has twin regulator posts, each of which you can close in the event of a regulator malfunction while still providing access to all the gas in both cylinders to the back up regulator. The isolator valve permits you to separate the cylinders and save half your gas in the event of a manifold leak on one side.

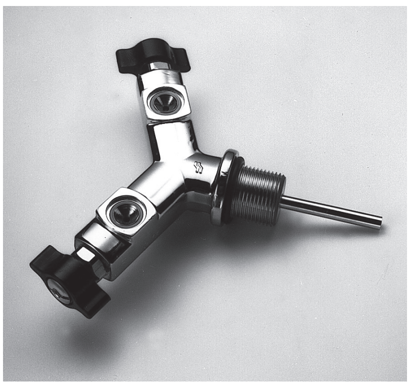
Twin cylinders, 11-12 litres/71.2-80 cubic feet each, are sufficient for many divers going no deeper than 50 metres/165 feet. Popular larger cylinders (18-21 litres/105-120 cubic feet each) are more common for longer dives, which require more gas on the bottom and for decompression.

The prime choice for a manifold (doubles valve) is the DIN (Deutches Industrie Norm) isolator manifold. This manifold uses the DIN system instead of the yoke, which is preferred because the captured o-ring is considered more reliable in the event of impact. The manifold has twin regulator posts, each of which you can close in the event of a regulator malfunction (runaway freeflow) while still providing access to all the gas in both cylinders to the back up regulator. The isolator valve permits you to separate the cylinders and save half your gas in the event of a manifold leak on one side.



The DIN (Deutches Industrie Norm) DIN system is preferred because the captured o-ring is considered more reliable than the yoke system in the event of impact.

In some areas, you may have difficulty finding isolator manifolds, but the twin regulator posts are considered mandatory equipment; the old fashioned single valve doubles manifold is unacceptable for tec diving. Likewise, mounting two singles in doubles bands isn't considered acceptable due to complexity in gas management, and the inability for one regulator to access all the gas in both cylinders. You'll be using doubles with an isolator manifold in this course.



A "Y" valve lets you mount two separate regulators on a single tank.

If you're tec diving with a high capacity single cylinder, choose an "H" or "Y" valve that lets you mount two separate regulators on a single tank, again with the DIN system preferred. (Obviously, there's nothing to isolate when using a single cylinder.)

Manifold Accessories. The prevailing practice is to keep things simple, so most of the tec diving community run the manifold as is. However, a few areas have specialized needs regarding tank valves. In the United Kingdom, for example, some wreck divers use guards to protect the manifold from impact inside of wrecks. Similarly, a cable for closing the isolator valve by remote has become popular because the combination of cramped wreck interiors and dry suits can make reaching the valve difficult or impossible.

Excepting these regionalized needs, you generally want to follow the standardized technical rig layout and methods to avoid clutter around the valves. You can't see this area while kitted up, so keeping it clean and simple is the best way to avoid problems. Note, for instance, that you *completely remove* valve covers and dust caps (from your regulators, too) rather than allow them to dangle from strings as do recreational divers.

Doubles Bands. Doubles are set up with steel bands with their mounting bolts 28 cm/11 inches apart (standardized to fit BCDs and back plates). You bolt the cylinders to your BCD and harness together with wing nuts on the mounting bolts.

Setting up doubles takes some training and finesse, so it's something you should leave to your PADI Dive Center or Resort, unless you're trained and qualified to set them up. Improperly set up doubles don't lie flat, making them awkward to work with, and the lack of proper alignment can make the manifold fail, resulting in a runaway leak.

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Regulators

In deep tec diving (and most other forms of technical diving), you should always have two fully independent regulators available. This doesn't include regulators you use on your decompression or stage cylinders. The reason why you want at least two is that you usually can't simply surface in an emergency as you can while recreational diving. Therefore, you need another way to breathe should one of your regulators malfunction.

You set up the right post regulator with a low pressure inflator hose to your BCD, and the second stage on a hose about two metres/seven feet long. You set up the left post regulator with the SPG and the second stage on a standard length hose.

Choose top of the line balanced regulators for maximum reliability and performance. Since you're ideally using a DIN manifold, you need DIN fitting regulators (simple adapters allow you to use them on yoke valves in a pinch.)

You set up the right post regulator (the one on the right side of the manifold when you're wearing the set) with a low pressure inflator hose to your BCD, and the second stage on a hose about two metres/seven feet long. You'll commonly hear this called simply your "long hose."

Set up the left post regulator with the SPG and the second stage on a standard length (about 80 cm/32 in) hose. A low pressure hose to your back up BCD and/or your dry suit comes off the left, if applicable. Otherwise, you have no low pressure inflator hose coming off of it. (More about these options shortly.) Note that there's only one second stage per first stage.

BCD and Harness

Your basic technical rig calls for a harness that sandwiches an interchangeable BCD bladder against the cylinders, everything bolted together via recessed wing nuts that screw onto the cylinder band mounting bolts. Many recreational BCDs don't meet the needs of tec diving (D-rings on the shoulders don't necessarily make a BCD a tec diving BCD). Although you usually invest in your BCD and harness as an integrated system, they're separate components with differing selection criteria.

BCD. Technical BCDs are sometimes called "wings" because they let you "fly" doubles and resemble stubby wings protruding from the tanks behind you. You choose your BCD based on your needs regarding size, single or double bladder, and unrestrained or bungeed design.

Size – You choose your BCD size based on having adequate lift to hold you at the surface wearing all the gear you need for the dive, and with all cylinders full. (In tec diving, the difference between having full and empty cylinders can be 7 kg/15 lbs or more.) You can choose different sizes based on your need so that you have adequate buoyancy, while not having way more than you need. A BCD that's too big just adds drag and can complicate buoyancy control.

You can choose different BCD sizes based on your need so that you have adequate buoyancy, while not having way more than you need.

Single or double bladder – You can also choose between single bladder and double (redundant) bladder BCDs. A single bladder has a single air cell and inflator, whereas the double bladder has a second air cell and inflator for back up (not to double your buoyancy — you always use one air cell at a time).

Whether you need a double bladder BCD (sometimes called "double wings") depends on the dive requirements. In all cases, you should have back up buoyancy. If, for example, dropping your weights in the event of BCD failure would still leave you substantially negative, then a double bladder BCD might be the best way to go. But, you still want the simplest rig that does the job. Typically, if you're in a dry suit with lighter cylinders, that may provide adequate back up buoyancy control and a single bladder can be appropriate. The heaviest cylinders can weigh too much to use a dry suit reliably for back up buoyancy control, or you may be diving in a wet suit. In those cases, the double bladder BCD provides the back up you need. If you dive in several environments, you may find you need both single and double bladder BCDs, using whichever one fits the circumstances.

You can choose between single bladder and double (redundant) bladder BCDs. A single bladder (right) has a single air cell and inflator, whereas the double bladder (left) has a second air cell and inflator for back up.

Although not commonly seen today, the original "double bladder" was accomplished by stacking two single bladder BCDs under the harness plate. This works adequately and is acceptable, but has fallen out of favor because it adds substantial bulk and drag. Some divers reduced the bulk by using a slightly smaller BCD for the back up.

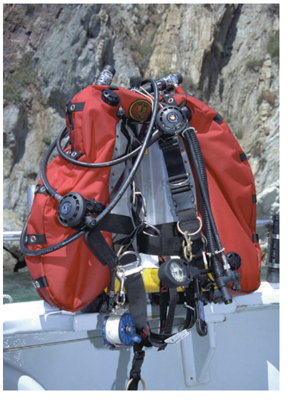
Unrestrained or "bungeed" BCDs – Bungeed wings have elastic or tubing that constricts the BCD to minimize its profile, while stretching to expand when you fill the BCD. Bungeed wings are useful in wreck penetration, for instance, to reduce snag potential, and the constriction squeezes air out of the bladder, making bungeed BCDs deflate more rapidly than unrestrained BCDs.

You choose between bungeed BCDs (left) and unrestrained BCDs (right). The model on the left is adjustable, and you can easily release the bungee if necessary.

However, there's much made in some circles about what happens with a hole or exhaust valve failure using a bungeed BCD. Unrestrained BCDs will usually still hold a fair amount of gas (depending on where the hole is), whereas bungeed BCDs tend to squeeze the gas out. Unrestrained BCDs lie flat against your cylinders when you're swimming, so they produce less water drag. Improperly rigged bungeed wings may not expand to their full size, leaving you with significantly less buoyancy than you thought; this can be hazardous. On the other hand, properly rigged bungeed wings still usually hold a good bit of air with a hole or exhaust valve failure, they expand to their full size when necessary, and they protrude less in the snagging environment of a wreck.

Again, keep it simple. If you need bungeed wings for a clear advantage, as in wreck penetration, then use them following the manufacturer specifications for setting them up. If you don't need them, then use an unrestrained BCD. With some, you can remove and replace the bungee system as needed. Some new, more sophisticated BCD wings offer the advantages of bungeed wings and unrestrained wings at the same time. With these, you adjust the bungees for the required buoyancy, and you can release the bungee system with a single cut, unrestraining them so they hold ample air with a failed exhaust valve or small puncture.

Harness. Your harness holds the BCD to the cylinders and everything on to you, so it has to be strong and reliable. Characteristics to consider include style, crotch strap availability, adjustable shoulder quick releases, adjustable D-rings and waist strap types.



The plate style harness (left) routes standard nylon webbing through a shaped back plate. It's simple, reliable and strong. The soft harness (right) is made of standard nylon webbing. It does the same job, but tends to be a bit more comfortable and versatile. By the way, the rigs are on the rail for picture purposes and secured from the behind.

Style – There are two acceptable styles: the plate and soft harness. The plate style (steel, aluminum or plastic) routes standard nylon webbing through a shaped back plate. It's simple, reliable and strong. The soft harness is made of standard nylon webbing. It does the same job, but tends to be a bit more comfortable and versatile, plus it's lightweight (a bonus for the traveling diver). However, it's not quite as simple, though simple enough to meet the standardized rig philosophy.

To handle the bulk and buoyancy distribution of doubles, choose a harness with a crotch strap.

Crotch strap – Not an option, but a necessity due to the bulk and buoyancy distribution of your doubles. If the harness won't take a crotch strap, find one that will.

Shoulder harness adjustable quick release connectors – Although most common on soft harnesses, you can get these on plate harnesses as well. They make it easier to get into and out of your rig, and you can usually adjust them while diving. Early versions didn't hold the weight of tec diving gear well, but that's not much of an issue today.

They're not needed for general diving, but convenient. If you opt for them, put a short piece of bungee or surgical tubing on the bottom of each side to keep the free end of the webbing from dangling. One instance where they can make an important difference is in a rescue situation. It's tough getting an unresponsive diver out of a standard harness — the rescuer may have no choice but to cut the straps; the quick releases alleviate this.

Although most common on soft harnesses, you can get adjustable, quick release buckles on plate harnesses as well. They make it easier to get into and out of your rig, and you can usually adjust them while diving. Note the bungee loop for tucking the free end, which reduces "danglies."

Adjustable D-rings at shoulders and waist – You need at least one, or a maximum of two D-rings on the harness shoulders, with the standoff (bent or rigid) D-rings the ideal because you can more easily get a clip onto them. You need a rigid D-ring on the waist strap at the hips, one on each side (these are usually vertical, but you can also get horizontal rigid D-ring systems — either does the job.) It's essential that you have D-ring locations where you need them to carry your stage/decompression tanks and accessories (more about these later). Therefore, fixed location D-rings aren't usually a good choice — with one exception: a few manufacturers make *custom* harnesses measured specifically for

You need at least one, or a maximum of two-D rings on the harness shoulders. They need to be in the right place, so you want D-rings you can adjust.

you, placing the shoulder D-rings exactly where you need them. This is still "adjustable" in that they're adjusted to you, then fixed in place.

If you're using adjustable quick release connectors, the shoulder D-rings go above the connector. You need to do this so you have unrestricted webbing to slide through the connector. When wearing a stage/deco bottle, this arrangement also keeps the rig on you if the connector were to separate (although that's highly unlikely with modern harnesses).

You need a rigid D-ring on the waist strap at the hips, one on each side, for attaching stage/deco cylinders and accessories.

Waist strap – Your harness should have standard webbing and a buckle as a waist strap. A removable "cummerbund" under the webbing is acceptable (most common on soft harnesses), but avoid a harness that has only a cummerbund (not as strong and creates gear positioning problems). Most tec divers remove optional cummerbunds. Many divers prefer a metal buckle to avoid breakage when moving heavy gear.

In choosing and setting up your BCD and harness, keep in mind that the wings may or may not be partially integrated into the harness. Integration is fine, provided you can choose the components described above as needed to fit your requirements. As mentioned, you may find you want two or three wings, or entirely separate BCDs and harnesses, to match differing requirements in differing dive environments.

If you're using adjustable quick release connectors, the shoulder D-rings go above the connector.

Exposure Suits

As in recreational diving, you choose an exposure suit for a tec dive based on the water temperature at depth and the dive duration. When you're new to tec diving, it's easy to underestimate your insulation requirements. What keeps you comfortable for a short recreational dive usually won't do it for a long tec dive.

You almost always need a good bit more insulation due to the duration, and because you spend much of the time making decompression stops where you don't exert much and warm up. It's not unusual to wear a dry suit in water that recreational divers find a wet suit more than adequate for, or to wear a full wet suit with hood when the recreational divers wear shorties.

Dry Suits. For the longest durations and colder water, you're going to need a dry suit. This sometimes provides the back up buoyancy control you need so you can dive with a single bladder BCD, and it gives you the option of using an argon inflation system for additional insulation.

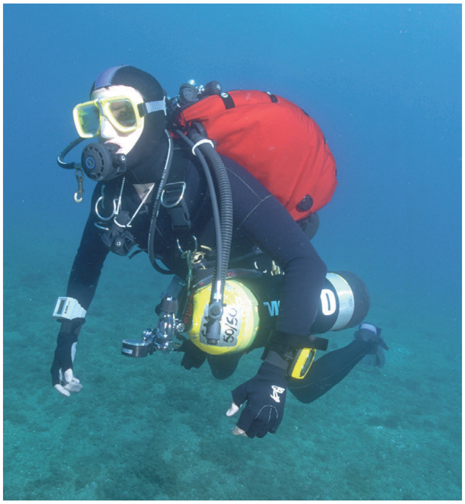
Dry suits require some training and experience to use properly. If they're new to you, take the PADI Dry Suit Diver course and master using dry suits in recreational diving before using one for tec. At least 20 dives is a conservative minimum experience with a dry suit before making a tec dive in one.

Even after mastering dry suit use in recreational diving, you'll need some new skills for tec diving in one, such as controlling both your BCD and your dry suit at the same time.

But even after mastering dry suit use in recreational diving, you'll need some new skills for tec diving in one. In recreational diving, you use only the dry suit for buoyancy control underwater. In a heavy weight tec kit, you'd look like the Goodyear Blimp if you tried that, so you use both the suit and your BCD at the same time. This calls for some valve juggling when ascending and descending, which is a more complex skill to master.

Wet Suits. For most tec divers, a full 6 mm/¼ in. farmer john (or other style with two layers over the torso) wet suit with hood will suffice in water 24°C/75°F or warmer, for two to three hours. Some divers find that they can even use a wet suit in substantially cooler water. Be sure to get a good quality suit made of durable neoprene that can withstand the rigors of compression and recovery caused by depth and pressure.

Wet suits add some buoyancy variables you need to account for. When wearing heavy weight rigs, dropping weights in an emergency (if you even need any!) may not give you sufficient buoyancy if your BCD fails. With lightweight rigs, dropping them may give you way too much, making it difficult to maintain a deco stop. Therefore, double wing BCDs are essential. At depth, your suit will



When diving in a wet suit, choose a double (redundant) bladder BCD.

be compressed so that it has little buoyancy, so you need to be sure your BCD has ample lift. You'll probably have a lot of gas in it. When you return to shallower water, the suit re-expands and buoyancy restores; you need ample weight so you don't spend your entire decompression stop trying to stay down. (You'll learn more about proper weighting for a tec dive in a bit.)

The advantage of wet suits is simplicity. You only need to control your BCD, and, when diving in environments that can be hard on a suit (like wrecks), you don't have to worry about chattering your teeth through an hour decompression because you snagged it and made a leak.

Weight Systems

Your choices in tec diving weight systems are similar to those in recreational diving, but with differences. For one, you may not need one at all, and in many instances, the mandatory quick release you learned to use in recreational diving becomes as much a liability as an asset.

With light rigs, like double aluminum cylinders, you will probably still need weights. With heavy weight rigs, you may not, depending on your exposure suit. Your choices, as in recreational diving, are the weight belt, the integrated weight system and the weight harness.

Weight Belt. The advantages of the standard weight belt are that it is simple, readily available and easy to adjust. It's a good choice when you don't need much weight. The disadvantages are that you have to put it on after you don your rig (otherwise you trap it under the crotch strap), and that it can be hard to position securely amid your other gear. The more weight on the belt, the more

One disadvantage of a weight belt is that you have to put it on after you don your rig, otherwise you trap it under the crotch strap. But, some tec divers intentionally trap the belt, judging that the risk of losing it by accident is higher than the risk of having to release the crotch strap to get rid of it.

these disadvantages become an issue. Regarding the crotch strap, as discussed shortly, *losing* your weights on a decompression dive can be a hazard. With that in mind, some tec divers intentionally wear their crotch straps over their weight belts for both convenience and to minimize risk of accidental loss. They do this knowing that it will slow down ditching the belt if necessary; they balance one risk against another.

Weight harnesses simplify kitting up because you don them before your rig, and they don't add weight to the rig.

Integrated Weight Systems. These systems integrate with your harness, so their advantages are that you don't need to put them on last, and they're already positioned amid the rest of your kit. The disadvantages are that you have to have a harness system that accepts integrated weights (many don't), and it makes an already heavy rig heavier. Also, you may find the weight system located in a less than ideal location, adding some clutter to your rig rather than streamlining it.

Weight Harness. The weight harness provides the key advantages of both the weight belt and weight system while eliminating some of the disadvantages. They simplify kitting up because you don them before your rig, and they don't add weight to the rig. The downside is that they can be awkward to adjust so the rig doesn't interfere with weight ditching, and they sometimes get a bit in the way when sliding into your kit.

Loss of Weights. Losing your weights can be a significant hazard on a decompression dive when you're in a lightweight rig. Accidental weight loss can make it difficult or impossible to control your ascent, much less maintain the depths for required decompression stops.

To avoid the possibility of accidental weight belt loss, many tec divers mount two buckles, both of which you must release to get rid of the belt. To them, the slightly slower ditching time is more than offset by the hazard it helps avoid.

To avoid this possibility with weight belts, many tec divers mount two buckles, both of which you must release to get rid of the belt. The slightly slower ditching time is more than offset by the hazard it helps avoid. Most weight systems and harnesses are less prone to accidental loss than weight belts, so you usually don't need to do this with them, though you can arrange some so their release mechanisms take two steps.

Similarly, as mentioned before, some divers *intentionally* wear their crotch straps over their weight belt. The drawback is that this would delay getting rid of it quickly in an emergency.

Instrumentation

Your basic deep technical kit instrumentation includes your SPG (on the left post regulator), compass, dive computer or timer/depth gauge, and back up computer or timer/depth gauge. You arm mount these (except your SPG, of course), and some tec divers carry their compass in a pouch or pocket.

As a rule, tec divers avoid consoles. They're bulky and protrude, creating drag and an entanglement hazard – quite contrary to the standardized technical rig philosophy. Instead, tec divers mount their gauges on their arms.

As a rule, tec divers avoid consoles. They're bulky and protrude, creating drag and an entanglement hazard — quite contrary to the standardized technical rig philosophy. To save arm space, however, tec divers sometimes mount two gauges on a single wrist strap. Some tec divers carry back up gauges clipped inside a pouch or pocket.

SPG (Submersible Pressure Gauge). You only have one of these because two creates the potential for two high pressure leaks. If your SPG fails, you'll end the dive immediately anyway.

The preferred SPG is the simple, mechanical type because it's reliable (no battery concerns). Few tec divers use air integrated computers, whether with hose or hoseless. They're electronic, tend to be bulkier, and if the gauge fails, you're out two, rather than one instrument.

Compass. Your standard full sized, liquid filled diver's compass does the job for most tec diving, though some tec diving (cave) calls for specialized compasses for surveying and mapping.

You should always have at least two methods for determining your time, depth and decompression requirements.

Timer and Depth Gauge. These may be separate instruments, though most tec divers prefer the integrated digital depth gauge and bottom timer. Digital watches suitable for scuba diving with a stop watch function provide a timer option, provided that they're rated to the depths you're planning to dive.

You use a timer/depth gauge in place of a dive computer when diving with tables, or you may use it with tables as back up to your computer. If you're using two computers, you don't also need a timer/depth gauge; but you should always have at least two methods for determining your time, depth and decompression requirements.

Dive Computers. At this writing, there are three types of dive computers suitable for the diving you'll be doing as a DSAT Tec Deep Diver or Apprentice Tec Diver: the standard air computer, the enriched air computer, and the multigas computer. Given the rapid changes in this technology, you may have more choices by the time you read this.

Single gas enriched air dive computers allow you to set for the EANx you're using, usually with up to 40 or 50 percent oxygen. They extend your no stop time and shorten your decompression when using EANx versus air.

Air computers – The basic air-only computer has the advantages of being simple, inexpensive and always yields a more conservative decompression profile when using enriched air nitrox. The downsides are that they're limited in the performance they offer, they can't extend your no stop limits or shorten your deco type with EANx, and they don't track your oxygen exposure.

Enriched air computers – These allow you to set for the EANx you're using, usually with up to 40 or 50 percent oxygen. Their advantages are that they extend your no stop time and shorten your decompression when using EANx versus air, and they're not as costly as multigas computers. The disadvantages are they cost more than air-only computers, and they're limited compared to multigas computers because they don't further extend your no stop time or shorten your decompression when you switch gases during the dive. They also can't track your oxygen exposure if you switch to a higher oxygen gas during the dive.

You can set multigas enriched air computers with three or more EANx blends or pure oxygen, allowing the computer to alter your decompression and oxygen exposure when you switch from one gas to another during the dive. They can extend your no stop time, accelerate your decompression based on the gas switches, and track your oxygen exposure.

Multigas computers – You set these computers with three or more EANx blends or pure oxygen, allowing the computer to alter your decompression and oxygen exposure when you switch from one gas to another during the dive. The advantages are that they can extend your no stop time, accelerate your decompression based on the gas switches, and track your oxygen exposure. This is the most versatile computer type for tec diving.

Multigas computer disadvantages are that they're also the most costly, and they are more complicated to use. This means more potential for error. Some types require you to link the dive computer to a personal computer to load it with the information for the dive.

You'll learn more about using all three types of computers as you go through the course.

The standard dive knife, if sharp and in excellent condition, will do the job for some tec diving, but, the trend is away from the big dive knife. When used, it usually goes on the inside of either calf.

Cutting Tools

By now you've noticed that technical divers are big on back ups, so it'll come as no surprise that you should have at least two cutting tools when tec diving. Of these, you want to carry at least one so you can retrieve and use it with either hand.

You have several options in cutting tools and where you wear them. The standard dive knife, if sharp and in excellent condition, will do the job. But, the trend in tec diving is away from the big dive knife (and it's never worn in cave diving); those who opt for it usually wear it on the inside of either calf so you can reach it with either hand, and so it's not prone to entanglement.

More commonly you'll see a small dive knife worn in a sheath near the center of the waist band where either hand can get it. With the setup shown, the sheath bands also hold the free end of the waist strap to improve streamlining.

More commonly you'll see a small dive knife worn in a sheath near the center of the waist band, again so either hand can get it, but sometimes on the harness shoulder. This knife is usually very sharp, so you have to be careful unsheathing and sheathing, since you may not be able to see the sheath. That is to say, don't accidentally cut your equipment or yourself.

The Z-knife, or hook knife, is a small bladed hook especially suited for cutting fine line. It's commonly mounted via gauge strap on the wrist or harness.

The Z-knife, or hook knife, is a small bladed hook especially suited for cutting fine line. It's commonly mounted on the wrist or harness.

EMT shears are heavy duty snips that can cut rope, or (for some models) even cable. Wreck divers especially go for these as an alternative to a knife, wearing it on the harness, calf or waist. They're also popular in cool water environments that make it hard to handle a knife while wearing thick gloves.

Since you can't see your waist very well, another option is to carry a bosun's knife or other folding knife in a sheath or pouch at the waist or under your instrument wrist straps. The

Another option is to carry a bosun's knife or other folding knife in a sheath or pouch at the waist or under your instrument wrist straps. The advantage of a folding knife is that closed, you can handle it safely even when you can't see it. You usually have a clip or wrist lanyard on it to prevent loss.

advantage of a folding knife is that closed, you can handle it safely even when you can't see it. You usually have a clip or wrist lanyard on it to prevent loss while handling, and most tec divers go for types that you can open with one hand. Since these aren't true dive knives, unless you opt for titanium, they need extra care to prevent excessive corrosion.

For specific dive objectives, you might carry a Leatherman®-type multi tool in a sheath or pouch on your waist band, or in a pocket with a clip. Typically these include a knife blade, pliers, wire cutters, a file, saw and some other tools. They're versatile, but can be difficult to open with gloves on. In selecting one, you might wear your dive gloves to see how well you manage.

For specific dive objectives, you might carry a Leatherman®-type multi tool in a sheath or pouch on your waist band, or in a pocket with a clip.

In selecting and mounting your cutting tools, keep in mind that different environments and objectives will call for different tools and mounting requirements. Your instructor can help you select the optimum cutting tools for the environment in which you train for the Tec Deep Diver or Apprentice Tec Diver certification.

Guidelines for Pockets, Clips and Accessories

As you gain experience in tec diving, you'll find that you're continuously needing to update what you carry and how you carry it to meet specific dive objectives and environmental configurations. Your goal is to stay with the rig-wreck, dive-cave philosophy — minimal drag, nothing dangles, everything out of the way but easy to get to when you need it. Try to apply these six guidelines:

Avoid large pocket pouches on your harness. If you need a pocket on your rig, choose a small pocket that slides back and out of the way.

1. Avoid large pocket pouches on your harness. These tend to add bulk and confusion to your rig and get in the way. If you need a pocket on your rig, like for a spare mask, choose a small pocket that slides back and out of the way.

The most useful pocket in tec diving is on the outside thigh of your exposure suit. Since it's well below your rig, you can get to it even when wearing multiple stage/deco cylinders.

2. The most useful pocket in tec diving is on the outside thigh of your exposure suit. Since it's well below your rig, you can get to it even when wearing multiple stage/deco cylinders. If your exposure suit doesn't have one, you can usually get one added, and some manufacturers make strap on thigh pockets that work well. If you'll be investing in a new exposure suit soon, be sure to order the pocket with it.

3. Use brass or stainless steel clips for your accessories and SPG. Mount the clip onto the accessory, not on the BCD or harness. Generally avoid plastic (not very strong) and chrome-plated (corrode and jam) clips.

4. Sliding gate clips (a.k.a. "dog clips") are generally preferred over marine snaps (a.k.a. "swinging gate clips) because they won't accidentally snap on to things by themselves like the latter can. (In some areas, wreck divers call marine clips "suicide clips" because they can potentially clip themselves to line or cable, entangling you underwater.) However, this is over emphasized, and a few tec divers use marine clips without any difficulties. In any case, all clips should be where you can access them (nothing outside of reach) because all clips can snag and you may need to disentangle them.

Accessories clipped to a D-ring should be well out of the way when stowed, and not dangle or create entanglement potential. As possible, try to put only one item per D-ring.

Keep the environment in mind. Smaller clips that you work easily with thin gloves in warm water may be impossible to open and close in cool water with thick gloves.

5. Accessories clipped to a D-ring should be well out of the way when stowed, and not dangle or create entanglement potential. If possible, keep an accessory in a pocket except when in use, and clip it to your harness only to free your hands momentarily, or to avoid dropping the item while using it. As possible, try to put only one item per D-ring.

6. Use a breakaway clip on anything you may need to discard or release in an emergency. To make a breakaway clip, connect the clip to the accessory or gauge via a small o-ring. In an emergency, a sharp tug breaks the o-ring to free the item, leaving the clip behind on the D-ring. Small pull ties break away easily with a 90 degree twist.

Use a breakaway clip on anything you may need to discard or release in an emergency. To make a breakaway clip, connect the clip to the accessory or gauge via a small o-ring. Small pull ties break away easily with a 90 degree twist. This item uses both.

Putting It All Together: Basic Rig Head-to-Toe

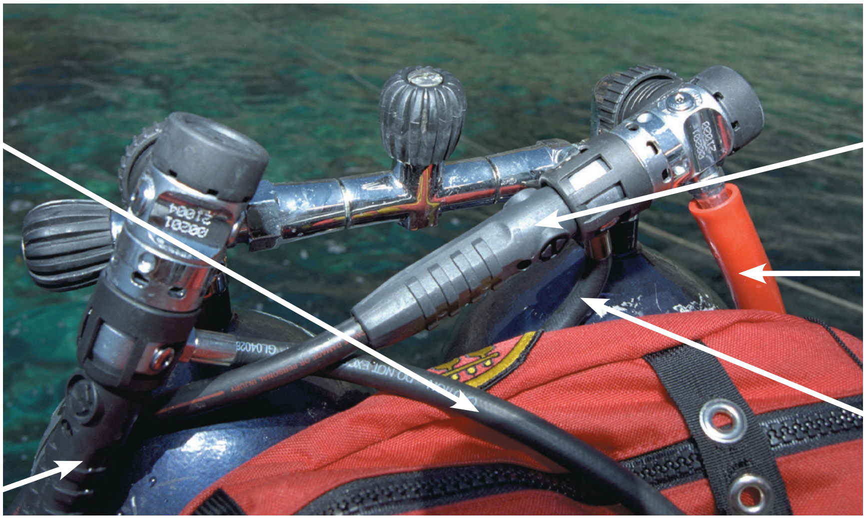
Okay, now that you've got the basics about your tec rig components, let's look at how it all fits together.

Regulators and Valves. Start with your short hose regulator on the left post. Your SPG goes straight down behind the BCD wing and mounts via breakaway clip on your left hip D-ring. (Some divers mount it up on a chest D-ring.) The second stage goes to the right and rests on your upper chest, held there by a bungee or surgical tubing necklace. If you're using double wings, the low pressure (LP) inflator hose goes to the right or straight down to the back up inflator mechanism (depends on its location). If you're using a dry suit, with most suits the LP inflator hose goes straight down, then back up at the left hip to the inflator. If you're using an argon system and a single bladder BCD, then there will be no LP inflator hose.

Your long hose regulator goes on the right post, so that the low pressure inflator hose goes to the left to the primary BCD inflator, and the long hose goes straight down behind the wings. From there it tucks under the right D-ring and safety reel (you'll learn more about safety reels in the next chapter), comes up across your chest, behind your neck on the left and around to your mouth from the right. Mount a breakaway clip where the second stage meets the hose for clipping it off when it's not in your mouth. When kitting up, you swing the long hose into place as your last step so that you're sure that no hoses or gear trap it by lying on top.

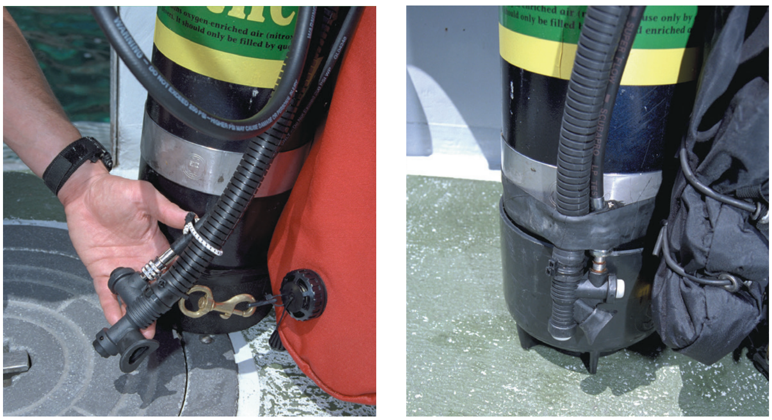
In mounting and rigging your regulators, note that all hoses come off the first stages so they go inward and/or downward — never outward so they protrude. Proper routing maintains your streamlining and minimizes entanglement hazard.

Open all the valves, including the isolator valve all the way. Do not close them back a partial turn like some used to do in recreational diving.



Mount your regulators so hoses route inward and downward.

BCD and Harness. Your primary BCD inflator hose comes over your left shoulder, retained (clip or strap) so you don't have to hunt for it, but easy to release so you can quickly dump gas. Your back up BCD (if used) inflator stays behind the BCD wing on the right or left (depends on how your BCD's laid out), clipped to the wing or bungeed to the cylinders. This avoids confusion with the primary (remember, you only use one at a time), while keeping the back up readily available. Some divers leave the back up BCD inflator hose disconnected, especially if using high volume inflators, to avoid an accidental runaway ascent if the inflator malfunctions. The drawback is that this adds a step if you have to switch to your back up in a hurry.



Secure the backup BCD inflator behind the bladder with either a snap (left), or by tucking it under inner tubing at the base of the cylinder (right).

If you're using a dry suit, ideally you want the BCD hose to be long enough that you can control both the BCD inflator and dry suit inflator at the same time with the left hand. This lets you add air to both at the same time as you descend, keeping your right hand free for other uses.

Pockets, if used, should be small and mounted at or near the hips as previously noted, well out of the way. Straps should be adjusted and/or trimmed so there's no excessive slack dangling from any slide or buckle. The crotch strap should normally be under your weight belt (if used — and some divers opt to wear it over the belt as discussed earlier). The harness height on the cylinders should be adjusted so that you can reach both regulator valves and the isolator valve. It's acceptable if you need to loosen your waist and/or crotch strap to do this.

Exposure Suit. If you're using an argon system, the argon cylinder mounts on the left side, valve down with the regulator inward so you can open the valve while wearing your rig (same as in recreational diving), though some divers prefer wearing it on the right because it matches their suit's layout better. Thread the LP hose to the dry suit inflator under your harness to eliminate protruding slack. Ideally, mount the system with a bracket that includes straps that you can cut (not all metal) to release it in an emergency.

As mentioned before, you'll find a thigh pocket the most useful pocket location in tec diving. It's also worth having knee pads; you'll find that you're especially hard on the knees in tec gear.

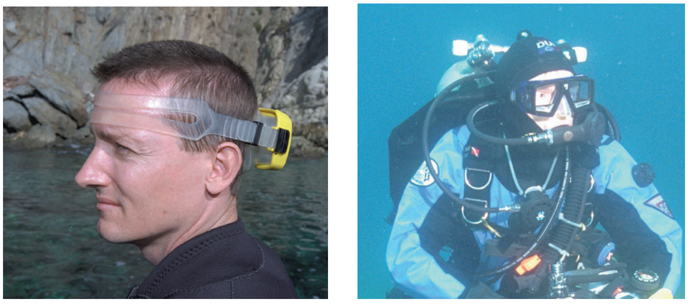
Instruments. Wear instruments on your arm on either side as you prefer. You may find that mounting all on one side, leaving one arm "clean" makes it easier to slide in and out of your rig (clean arm goes in last kitting up, and comes out first getting out). In some instances (such as scootering in a cave), arm choice may be more important for procedural reasons, but these cases don't apply to this course.

In setting up your instrument stack, if you plan to use it, put your compass so you can center it with your body line for accurate navigation. Otherwise, it's cleaner to opt to carry it in your thigh pocket if you don't plan to use it — but you should have it in case you need it. Keep in mind that you can put more than one gauge on a single strap. Remember that you should have information back up with either two dive computers, one computer and one depth gauge/timer/tables, or two depth gauges/timers/tables.

Mask and Fins. Forget the snorkel for most dives. If possible, you can wear your mask strap under your wet suit hood (not all hoods will let you do this, though), which minimizes the chance of slipping off, and helps keep it in place even if the strap breaks. If you have a spare mask, it tucks in an out-of-the-way harness pocket or thigh pocket (more about spare masks in the next chapter.)

Preadjust your fins. If they're not adjustable while wearing them, tape or otherwise secure the straps so they can't slip. Inspect the straps frequently (and the mask strap); they're one of the most common but avoidable gear failure points.

When you're in the water, your mask is on your face. Period. But, when you're gearing up or just after getting out, you may want it handy but out of the way. Many tec divers simply put it on backward, with the strap across their forehead, until they need it.



Before the dive, you can stick your mask on the back of your head to keep it with you, but out of the way (left). Many tec divers prefer to wear the mask strap under their hoods while diving (right).

Weight System. If you use weights, the weights need to be secure, but free and clear for ditching. If you're using a back up buckle on a weight belt, check that it's secure.

Cutting Tools. You should have two, mounted appropriately for the type, with at least one retrievable by either hand.

This describes the basic rig used by most tec divers, though there are regionalized variations for different types of environments. As you'll discover in the training dives, standardization plays an important part in how you function, particularly when following procedures in an emergency. Therefore, any departures from standard rigging need to be discussed with and agreed upon by your dive team.

Maintenance

Take care of your gear and your gear takes care of you.

That's the mantra of leading tec divers the world over; make it yours, too. Here are four recommendations regarding equipment maintenance:

1. Maintain it according to the manufacturer specifications.

2. Have regulators, valves, BCDs and gauges inspected and serviced/overhauled (as appropriate) at least annually, or more frequently for heavy use or as manufacturer specified.

ONE

3. Have any equipment that doesn't appear to function normally inspected and serviced before using it.

4. Never dive with gear in anything but top shape. Doing otherwise raises your risk of injury — or death — because you're starting the dive with a potential problem. Diving with gear in less than ideal working order is essentially using your back up from the start of the dive. That's outright stupid — if your back up has no back up, then guess what. You're diving without a back up. Diving without back up is what injures and kills divers in technical diving environments. Don't be stupid.

Tec Exercise – 1.2

1. You apply the standardized technical rig philosophy to ______________ ____________ and ______________ __________ due to _____________ _____________ ___________.

2. When choosing mask, fins and snorkels for tec diving you want (check all that apply):
   - ☐ a. a compact, high quality scuba mask.
   - ☐ b. full size power fins.
   - ☐ c. a flex snorkel with a wide bore.
   - ☐ d. fins without vents.

3. The prime choice for a manifold is a(n) ______________ system _________ manifold.

4. You want at least ___________ independent regulators when tec diving. The one on the ____________ side has the ______________ hose that you breathe from and hand to a team mate in an emergency.

5. You choose a BCD for your individual and environmental needs based on these characteristics (check all that apply):
   - ☐ a. size
   - ☐ b. ballistic material
   - ☐ c. single or double bladder
   - ☐ d. unrestrained or bungeed design

6. You choose your harness considering these characteristics (check all that apply):
   - ☐ a. style
   - ☐ c. crotch strap availability
   - ☐ b. adjustable D rings
   - ☐ d. waist strap types

7. When diving in a ________ suit, you should always have a double wing BCD.

8. Of your weight system options, the one that's simplest and easiest to adjust is:
   - ☐ a. the weight belt.
   - ☐ b. the integrated weight system.
   - ☐ c. the weight harness.
   - ☐ d. None of the above.

9. When tec diving, you'll generally use wrist mount gauges (excepting your SPG) that include a compass and two ways of monitoring depth, time and decompression requirements.
   ☐ True ☐ False

10. Of the three types of computers suitable for the tec diving you'll be qualified for as a Tec Deep Diver, the ______________ computer offers the most versatility, but costs the most and is the more complex to use.

Tec Exercise – 1.2 continued

11. Which of the following statements is NOT true?
    - ☐ a. You should have at least two cutting tools when tec diving.
    - ☐ b. You can carry a Z-knife for cutting lines quickly.
    - ☐ c. At least one cutting tool should be accessible by either hand.
    - ☐ d. The standard large dive knife is never acceptable in tec diving.

12. Guidelines regarding pockets, clips and accessories include (check all that apply):
    - ☐ a. Use a thigh pocket on your exposure suit rather than a large pouch on your harness.
    - ☐ b. Mount brass or stainless steel clips to accessories, not to your BCD or harness.
    - ☐ c. Choose sliding gate clips over marine snaps.
    - ☐ d. Put breakaway clips on anything you might need to ditch or release in an emergency.

13. Recommendations for maintaining your gear include (check all that apply):
    - ☐ a. Maintain it according to manufacturer specifications.
    - ☐ b. Have regulators, valves, BCDs and gauges inspected and serviced annually.
    - ☐ c. Have any equipment that doesn't appear to function normally inspected and serviced before using it.
    - ☐ d. Never dive with gear in anything but top shape.

14. Which of the following statements is not true?
    - ☐ a. The LP hose to your primary BCD inflator comes off the right post regulator.
    - ☐ b. Your primary regulator has a breakaway clip where the second stage meets the hose.
    - ☐ c. Open all valves, including the isolator, all the way, without closing them back a partial turn.
    - ☐ d. Always route hoses from the first stage outward and upward so they don't interfere with each other.

Check it out:
1. minimize confusion, procedural error, equipment task loading. 2. a, b. c is not true because you don't use a snorkel at all; d is not true because vents or their lack is not an issue. 3. DIN, isolator. 4. two, right, long. 5. a, c, d. b is not true because material is not generally an issue. 6. a, b, c, d. 7. wet. 8. a. 9. True. 10. multigas. 11. d. The standard large dive knife is not acceptable in some forms of tec diving, but it is acceptable in others. 12. a, b, c, d. 13. a, b, c, d. 14. d. You always run your hoses inward and downward so they don't protrude.

As a Tec Deep Diver, you'll be using various blends of EANx and oxygen to maximize your no stop time, to minimize your decompression and to accelerate your decompression. As an Apprentice Tec Diver, you'll learn to switch EANx blends to extend your no stop dive time.

Gas Planning I

Most technical deep diving wouldn't be feasible without the ability to select the gas blends you need. If you could only use air, you'd have less reliability in your decompression (i.e. a higher DCS risk), and you might not be able to carry enough gas to complete your decompression. As a Tec Deep Diver, you'll be using various blends of EANx and oxygen to maximize your no stop time, to minimize your decompression and to accelerate your decompression. As an Apprentice Tec Diver, you'll learn to switch EANx blends to extend your no stop dive time.

This section begins developing your gas planning skills, starting with a review of concepts and terms you already know from previous training. From there, you'll move into new territory, particularly involving oxygen exposure and how you track it.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is an Equivalent Air Depth (EAD) and how do you find it?
2. What are the maximum recommended oxygen partial pressures for deep technical diving?
3. What determines the maximum depth you can use an enriched air blend during the working (bottom) phase of the dive?
4. What determines the maximum depth you can use an enriched air blend during the decompression/ safety stop phase of a dive?
5. How do you find your Surface Air Consumption (SAC) rate?
6. How do you use your SAC rate to estimate your gas supply requirements for a given depth and time?
7. How do you determine your reserve gas supply ?
8. How do you determine how much gas a cylinder has?
9. What are CNS oxygen toxicity and pulmonary oxygen toxicity, and what causes each?
10. What are the signs and symptoms of CNS oxygen toxicity?
11. What are the signs and symptoms of pulmonary oxygen toxicity?
12. What is the so-called "CNS clock"?
13. What are Oxygen Tolerance Units (OTUs)?
14. What methods do you use for managing oxygen exposure?
15. What is the primary way you avoid CNS oxygen toxicity while diving with air, enriched air or pure oxygen?

Equivalent Air Depth (EAD)

In your PADI Enriched Air Diver course, you learned that an EAD (Equivalent Air Depth) is an adjusted depth you use on air tables when using enriched air nitrox. For a given actual depth with enriched air, the EAD is the depth at which air has the same nitrogen partial pressure (PN_2). You use the EAD depth, rather than the actual depth, to determine your no stop limits and repetitive dive status with air tables. EANx has less nitrogen than air has, so the EAD is shallower than actual depth — hence the longer no stop times.

There are two ways to find EADs, and two methods that provide your decompression information without the need for EADs. The first is to use the EAD formulas:

METRIC

$$\text{EAD} = \frac{(\text{1-fraction of oxygen}) \times (\text{Depth in metres} + 10)}{.79} - 10$$

IMPERIAL

$$\text{EAD} = \frac{(\text{1-fraction of oxygen}) \times (\text{Depth in feet} + 33)}{.79} - 33$$

(If you need a refresher in using the EAD formula, see the PADI Enriched Air Diver Manual. Remember to express the fraction of oxygen as a decimal; e.g., 32% oxygen, use .32.)

Although the EAD formula does the job, you know from your own experience that you don't use it about 99.9999999% of the time because it's a pain in the rear and seldom produces a meaningful benefit. In reality, you simply look the EAD up on a table such as the DSAT Equivalent Air Depth Table (for EANx30 through EANx40), or the Equivalent Air Depth and Oxygen Management Table in the appendix of this manual (air through 100 percent oxygen).

For instance, what's the EAD for 18 metres/60 feet if you're diving with EANx29? Using the Equivalent Air Depth and Oxygen Management Table, you should quickly find that it is 15.2 metres/51 feet. If you need a review on finding EADs, see the PADI Enriched Air Diver Manual and/or your instructor. It's crucial that you're able to do so for this course and for this type of diving.

METRIC

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC

OXYGEN CONTENT 29%				
Depth	EAD	PO2	OTU / Min	CNS% Min
3	1.7	0.38	—	0.00%
5	3.5	0.44	—	0.00%
6	4.4	0.46	—	0.00%
9	7.1	0.55	0.15	0.14%
12	9.8	0.64	0.34	0.17%
15	12.5	0.73	0.52	0.22%
18	15.2	0.81	0.68	0.28%
21	17.9	0.90	0.83	0.28%
24	20.6	0.99	0.98	0.33%
27	23.3	1.07	1.12	0.42%
30	25.9	1.16	1.26	0.48%
33	28.6	1.25	1.40	0.55%
36	31.3	1.33	1.53	0.67%
39	34.0	1.42	1.66	0.83%
42	36.7	1.51	1.79	2.22%
45	39.4	1.60	1.92	2.22%

IMPERIAL

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL

OXYGEN CONTENT 29%				
Depth	EAD	PO2	OTU / Min	CNS% Min
10	6	0.38	—	0.00%
15	10	0.42	—	0.00%
20	15	0.47	—	0.00%
30	24	0.55	0.16	0.14%
40	33	0.64	0.35	0.17%
50	42	0.73	0.52	0.22%
60	51	0.82	0.69	0.28%
70	60	0.91	0.84	0.33%
80	69	0.99	0.99	0.33%
90	78	1.08	1.13	0.42%
100	87	1.17	1.27	0.48%
110	96	1.26	1.41	0.55%
120	105	1.34	1.55	0.67%
130	113	1.43	1.68	0.83%
140	122	1.52	1.81	2.22%
150	131	1.61	1.94	2.22%

One way to get the decompression information you need for a particular enriched air blend is to use desk top decompression software, which you'll be learning to use as you get further into the Tec Deep Diver course. Desk top deco software generates custom tables for the particular enriched air blend or blends you're using, eliminating the need for EADs altogether.

Similarly, an enriched air dive computer automatically determines EADs as part of its calculations, so as you realize, you don't need EADs to use it. However, you may still need EADs if your back up deco information employs an air table.

An enriched air dive computer automatically determines EADs as part of its calculations, so you don't need EADs to use it. However, you may still need EADs if your back up deco information employs an air table.

Atmospheres and Bar

By convention, whether in a metric system or an imperial system country, the international dive community uses "atmospheres absolute" (ata) to express gas partial pressures and absolute pressure at depth. Although there's technically a slight pressure difference between a bar and an atmosphere, for the purposes of diving you can consider ata and bar as the same thing.

Note that all other pressure references, such as cylinder pressures, use bar for the metric system and psi (pounds per square inch) in the imperial system.

Maximum Blend Depth

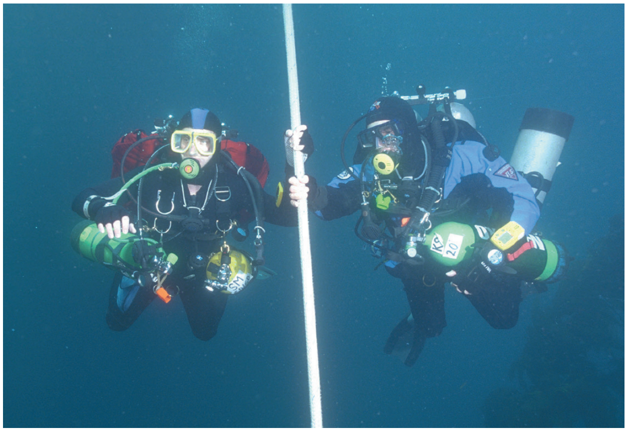
You also recall from your PADI Enriched Air Diver course that in recreational enriched air nitrox diving, the maximum allowable oxygen partial pressure (PO_2) is 1.4 ata. The Maximum Depth for using a particular blend of enriched air when recreational diving is determined by the depth at which the PO_2 reaches 1.4 ata.

In tec diving, things differ a bit. During the bottom or working part of the dive, the maximum allowable PO_2 is 1.4 ata, just as in recreational diving. And, just as in recreational diving, limiting your maximum PO_2 to less than 1.4 ata is always a good idea, especially if swimming or working hard (exertion is thought to predispose you to oxygen toxicity).

However, during decompression, a higher PO_2 is considered acceptable because you're relaxed and not exerting yourself. For decompression purposes, the maximum depth that you can use an EANx blend is the depth at which that blend reaches a PO_2 of 1.6 ata. However, keep in mind that this assumes that you'll be at rest. It's a good idea to be more conservative and use a lower maximum PO_2 when possible, especially if there's a good chance that you'll be exerting yourself during decompression. If you're using enriched air for extra conservatism rather than accelerated decompression (more about these in chapters to come), limiting your decompression PO_2 to 1.4 ata is easy and offers some added conservatism.

Remember that oxygen toxicity is unforgiving. If you had to choose, it's better to get DCS (which is usually treatable) than an underwater convulsion that leads to drowning (which is usually untreatable).

Incidentally, in the imperial system tec divers routinely treat 20 feet as the maximum depth for 100 percent oxygen and make their first



Remember that oxygen toxicity is unforgiving. If you had to choose, it's better to get DCS (which is usually treatable) than an underwater convulsion that leads to drowning (which is usually untreatable).

oxygen stop (if using it) at that depth. Technically, the PO_2 of pure oxygen at 20 feet of sea water is 1.61 ata. The .01 difference is ignored first because it's physiologically insignificant, and second because the difference between 1.61 and 1.6 ata is less than three inches!

Finding Your Maximum Depth. As you already know from your PADI Enriched Air Diver course, you can find your Maximum Depth by using formulas:

METRIC

$$\text{Bottom max depth (1.4 ata)} = \left(\frac{14}{\text{fraction of oxygen}}\right) - 10$$

$$\text{Deco max depth (1.6 ata)} = \left(\frac{16}{\text{fraction of oxygen}}\right) - 10$$

IMPERIAL

$$\text{Bottom max depth (1.4 ata)} = \left(\frac{46.2}{\text{fraction of oxygen}}\right) - 33$$

$$\text{Deco max depth (1.6 ata)} = \left(\frac{52.8}{\text{fraction of oxygen}}\right) - 33$$

You should already be familiar with using these, but like EADs, in reality you almost never use them, instead opting to find them more easily on tables such as the DSAT Equivalent Air Depth Table (EANx30 through 40) or the Maximum Depths Tables found in the Appendix of this manual. Most desk top decompression software will also tell you maximum depths for a given blend.

MOD, Maximum Depth, Maximum What The . . .?

Maximum Depth, Maximum Operating Depth, MOD — they're all names for the same thing. Originally the label "Maximum Operating Depth" got pasted on the depth at which you reach a PO_2 of 1.4 ata/1.6 ata. However, that's a bit long winded, so divers (who love to create long names for everything but then actually use a short form) began abbreviating two ways: The first was to use "MOD" (Just what we needed! Another acronym!), and second was to drop the word "operating," which is superfluous.

ONE

What's the maximum bottom depth (1.4 ata) and decompression depth (1.6 ata) for EANx75? Using the Maximum Depths Tables, you should find 9 metres and 11 metres/29 feet and 37 feet, respectively. As with EADs, if you don't recall how to find Maximum Depths, see the PADI *Enriched Air Diver Manual* and/or your instructor. It's crucial that you're able to do this for this course and for this type of diving.

METRIC

MAXIMUM DEPTHS IN METRES OF SEAWATER

BLEND	@1.4	@1.6
60%	13	17
61%	13	16
62%	13	16
63%	12	15
64%	12	15
65%	12	15
66%	11	14
67%	11	14
68%	11	14
69%	10	13
70%	10	13
71%	10	13
72%	9	12
73%	9	12
74%	9	12
75%	9	11
76%	8	11
77%	8	11
78%	8	11
79%	8	10
80%	8	10

IMPERIAL

MAXIMUM DEPTHS IN FEET OF SEAWATER

BLEND	@1.4	@1.6
60%	44	55
61%	43	54
62%	42	52
63%	40	51
64%	39	50
65%	38	48
66%	37	47
67%	36	46
68%	35	45
69%	34	44
70%	33	42
71%	32	41
72%	31	40
73%	30	39
74%	29	38
75%	29	37
76%	28	36
77%	27	36
78%	26	35
79%	25	34
80%	25	33

The T Formula

In tec diving, you'll often find yourself trying to determine your PO_2 at a specific depth for a specific gas blend, or trying to determine at what depth you reach a specific PO_2 with a specific gas blend, or trying to determine what gas blend you would use for a specific PO_2 at a specific depth.

The tables and formulas you learn to use in this course simplify this, but in a pinch there's one formula that will answer all these for you. It looks like this:

$$\frac{PO_2}{FO_2 \mid P}$$

Where:

PO_2 = partial pressure of oxygen in ata
FO_2 = the fraction of oxygen in the blend
and P = absolute pressure in ata

Remember that your absolute pressure is the depth:

METRIC
(D + 10) ÷ 10 = absolute pressure in ata (bar)
and (ata x 10) -10 = D

IMPERIAL
(D + 33) ÷ 33 = absolute pressure in ata
and (ata x 33) -33 = D

To use the formula, simply cover what you want to find and do what's left. If you want the PO_2, multiply the fraction of oxygen by absolute pressure (depth). If you want the absolute pressure (depth), divide the PO_2 by the fraction of oxygen. If you want the fraction of oxygen, divide the PO_2 by the absolute pressure.

For example:
What's the PO_2 using EANx40 at 10 metres/33 feet?

FO_2 = .4, P = 2 ata., .4 x 2 = .8 PO_2

Using EANx40, at what depth do you reach a PO_2 of .8?

FO_2 = .4, PO_2 = .8, .8 ÷ .4 = 2 ata, 2 ata = 10 metres/ 33 feet

If diving to 10 metres/33 feet, what percent oxygen do you need to have a PO_2 of .8?
PO_2 = .8, P = 2 ata, .8 ÷ 2 = .4 (40 percent)

Gas Consumption

During the PADI Deep Diver course and in the PADI *Deep Diver Manual*, you learned the basics of gas planning and determining your gas consumption rate. It's a useful skill in recreational diving, but to a degree optional in that when your SPG says it's time to go, you go. It usually doesn't matter (at least from a safety standpoint) if you breathe faster than you thought, provided you keep an eye on your SPG and adjust your dive so you begin your ascent with enough time to ascend slowly and make a safety stop at 5 metres/15 feet.

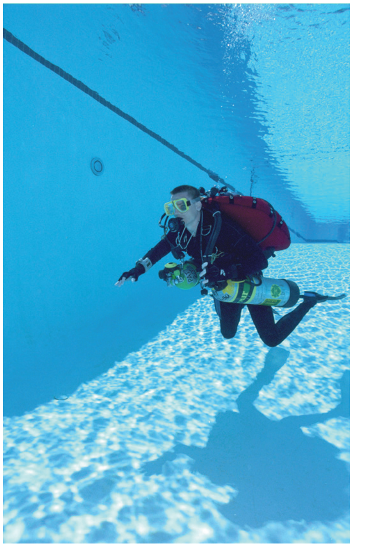
Planning your gas consumption becomes much more important in technical deep diving. Put simply, if you owe 30 minutes hang time but have only enough gas to stay 15 minutes, you're in a world of hurt. As part of the Tec Deep Diver and Apprentice Tec Diver courses, you'll learn to plan how much gas you need based on how fast you consume it at the surface and at depth.

SAC Rate and RMV. Step one in making sure you have enough gas for a dive is determining how fast you use it. This is most commonly done with your Surface Air Consumption (SAC) rate, also referred to as your Respiratory Minute Volume (RMV).

Your SAC rate is the rate you use gas (in litres or cubic feet per minute) when swimming at a moderate speed in all your equipment at 0 metres/feet. Equipment and anything that affects your profile will affect your SAC rate, and your SAC rate changes as you gain skill, become more fit and with variables such as water temperature. Your SAC rate also differs from the working part of the dive (when you're swimming a lot) and the decompression part of the dive (when you're reasonably still). SAC rate can also be calculated in bar/psi per minute, but that's not useful in tec diving because that assumes you're using the same type cylinder (pressure and volume) for every dive. That almost never happens in tec diving, so your SAC rate should be based on volume (litres/cubic feet).

Respiratory Minute Volume (RMV) is defined as:

RMV =	**Vt -Vd x respiratory rate**
where Vt =	**tidal volume**
Vd =	**respiratory dead air space**
respiratory rate =	**breaths per minute.**



The only way to find your SAC rate is to gear up, get wet and use your SPG, depth gauge and watch.

Tec divers sometimes use RMV interchangeable with SAC rate (based on volume). This isn't technically accurate, but close enough and no big deal. Just don't confuse SAC rate based on psi/bar with SAC rate/RMV based on volume. They're not the same thing.

Finding Your SAC Rate. The only way to find your SAC rate is to gear up, get wet and use your SPG, depth gauge and watch. Do this: Put on all the equipment you'll be using, then swim at a moderate pace (not taking it easy, but not getting out of breath) at a level depth for at least ten minutes, noting your SPG pressure when you start and when you finish.

Now all you have to do is plug your depth, time and the pressure you used into this formula, which converts the higher gas consumption at depth, bar/psi consumed and the total time into your volume per minute, surface rate. If you're Metric/Imperial bilingual, you'll note a slight difference in how the formulas work, which comes from the different conventions for referring to cylinder capacity in the two systems.

METRIC

$$\text{litres per minute SAC} = \frac{\text{bar used x total cylinder capacity litres}}{(\text{depth in metres} + 10) \div 10} \div \text{min}$$

Example: **You use 25 bar with twin 12 litre cylinders (total 24 litres capacity) while swimming at 15 metres for 10 minutes.**

$$\frac{25 \times 24}{(15 + 10) \div 10} \div 10 = \frac{600}{2.5} \div 10 = 24 \text{ litres per minute SAC rate}$$

IMPERIAL

$$\text{cubic feet per min SAC} = \frac{(\text{psi used} \div \text{working pressure}) \text{ x total cylinder capacity}}{(\text{depth in feet} + 33) \div 33} \div \text{min}$$

Example: **You use 370 psi with twin 71 cubic foot cylinders (142 total capacity, working pressure 2475 psi) while swimming at 50 feet for 10 minutes.**

$$\frac{(370 \div 2475) \times 142}{(50 + 33) \div 33} \div 10 = \frac{21.2}{2.5} \div 10 = .84 \text{ cubic feet per minute SAC rate}$$

You may recall that in the PADI Deep Diver course, you determined your SAC rate in bar or psi instead of *volume* per minute. This really simplifies things, but as mentioned before, SAC rate based on bar or psi assumes you're always using the same type of cylinder (same capacity and working pressures). This doesn't cut it in tec diving because not only can't you be sure you'll use the same type cylinder from one dive to the next, but more than likely, you'll have different type cylinders in a single dive! Volume per minute lets you apply your SAC rate to whatever cylinders you happen to be using.

Your SAC rate while holding still — like when making a decompression or safety stop — will be considerably less than your working SAC rate. Therefore, you may want to determine your SAC rate at rest for planning decompression/safety stop gas consumption. That is, you'll have a *working* SAC rate and a *decompression* SAC rate. When using your SAC rate (which you'll get into in a moment), you adjust your SAC rate up (or down, sometimes) based on your expected exertion. When in doubt, estimate upward, of course.

Your SAC rate will change as you gain experience and when you make substantial equipment changes, so you need to recheck it periodically. During this course, you'll calculate your SAC rate several times — don't be surprised if it's never exactly the same twice. With each calculation, though, you'll find yourself zeroing in on working and deco SAC rates that you can employ reliably.

Estimating Your Gas Requirements for a Given Depth. To estimate your gas requirements for a given time at a given depth, you'll use your SAC rates, with some decompression software use, too.

Estimating your gas requirement is simply a matter of plugging your planned depth, time and SAC rate into the following formula:

METRIC

litres required
= (min x SAC rate) x ((depth in metres + 10) ÷ 10)

***Example*: If your SAC rate is 22 litres per minute, how much gas supply do you need for 15 minutes at 33 metres?**

litres required = (15 x 22) x ((33 + 10) ÷ 10)

litres required = 330 x 4.3

litres required = 1419

IMPERIAL

cubic feet required
= (min x SAC rate) x ((depth in feet + 33) ÷ 33)

***Example:* If your SAC rate is .77 cubic feet per minute, how much gas supply do you need for 15 minutes at 110 feet?**

cubic feet required = (15 x .77) x ((110 + 33)/33)

cubic feet required = 11.6 x 4.3

cubic feet required = 49.9

Using the formula is pretty straightforward for a single depth dive, but becomes a pain in the wazoo when you start figuring out multiple levels, ascents and decompression stops. In the next chapter, you'll learn to estimate your gas supply requirements based on multiplying your SAC rate by conversion factors from the SAC Conversion Factors Table in the Appendix. It's much simpler.

Determining Your Reserve Gas Supply.

Life would be wonderful if your estimates were always exact and your dive always went as planned. But to allow for the unforeseen — delays, higher gas consumption than expected, going deeper than planned requiring more decompression than planned — you always plan for a reserve. You plan a given percent of your gas purely for emergencies — the higher the planned percent, the higher the reserve. If your dive goes as planned, you should have your entire reserve left. If you *think* your dive goes as planned, but you end up having used some of your reserve, then it didn't go as planned. (Chances are your SAC rate was off.)

The most common reserve in tec diving is a one-third (33 percent) reserve. This is called the "rule of thirds," and it means that you save one third of every gas you carry purely for contingency use.

To determine your gas requirements with reserve for a given depth use this formula:

$$\frac{\text{gas volume required}}{(1 - \text{reserve})} = \text{total gas}$$

METRIC

***For example:* If you estimate you need 1419 litres of a gas, what's your gas requirement with a 33 percent reserve?**

$$\frac{1419}{(1 - .333)} = \frac{1419}{.667} = 2127.4 \text{ litres}$$

IMPERIAL

***For example:* If you estimate you need 49.9 cubic feet of a gas, what's your gas requirement with a 33 percent reserve?**

$$\frac{49.9}{(1 - .333)} = \frac{49.9}{.667} = 74.8 \text{ cubic feet}$$

For the rule of thirds (which you'll probably use most of the time), you can simplify the formula as:

$$\text{gas volume required} \times 1.5 = \text{total gas}$$

This works because, as is painfully obvious at an effortless glance if you're a mathematical whiz, multiplying by 1.5 is the same as dividing by .66. If you're like all the rest of us normal people, take our word for it or redo the previous examples multiplying by 1.5 and prove it for yourself.

Actual Gas Supply

It's one thing to know how much gas you need, and another to know how much you actually have — what you've got when you start the dive. Fortunately, it's pretty easy to figure out, though somewhat different in the metric and imperial systems because of the way they designate cylinders.

Metric System. Tanks are designated by their nonpressurized internal volume in litres. Simply muliply the designated volume by the pressure in bar; for doubles, multiply that by two:

Example: **An 11 litre cylinder has 185 bar in it. What is the available gas supply?**

> ***Answer:*** **2035 litres. (11 x 185 = 2035 litres).**

Imperial System: Tanks are designated by their capacity in cubic feet at their working pressure. One way to find out how much gas you have is to divide the actual pressure by the working pressure and multiply that by the designated capacity. (A/W x C = cubic feet)

Example: **An 80 cubic foot cylinder, working pressure 3000 psi, has 2500 psi in it. What is the available gas supply?**

> ***Answer*****: 66.66 cubic feet. (2500 ÷ 3000 = .8333, .8333 x 80 = 66.66 cubic feet).**

Another, somewhat more popular method is the baseline method; a baseline is how many cubic feet cylinders hold per psi, which you multiply by the actual psi.

To get a baseline, divide the designated capacity by the working pressure. Then muliply the result by the actual pressure.

Example: **An 80 cubic foot cylinder, working pressure 3000 psi, has 2500 psi in it. What is the available gas supply?**

> **Answer: 66.8 cubic feet. (To get the baseline: 80 ÷ 3000 = .0267; .0267 x 2500 = 66.75)**

Note the slight difference with the previous example due to rounding.

For doubles, simply double the capacity when determining the baseline, or double the baseline number for the single cylinder.

Example: **A set of double 80 cubic foot cylinders, working pressure 3000 psi, have 1850 psi in them. What is the available gas supply?**

> ***Answer:*** **98.6 cubic feet. (To get the baseline: 80 x 2 ÷ 3000 = .0533; .0533 x 1850 = 98.6)**

The advantage of the baseline method is that you can determine the baselines for the cylinders you use frequently and record them in your log book. Then you only have to mulitply the cylinder baseline by your SPG reading to determine how much gas volume you have.

Keep in mind that the popular designation may be rounded. (Example, some types of the imperial system aluminum "80" actually hold 78.2 cubic feet at the working pressure). And, the same cylinders in one region may have a slightly different designation in another, though the actual capacity is the same. This normally isn't a huge issue, but may be if your required gas supply and supply available are real close.

If you find the gas supply available isn't adequate for the dive you've planned, you need to re calculate a shorter dive, or get more gas to cover the dive.

Oxygen Toxicity

In your PADI Enriched Air Diver course, you learned that breathing gases with high oxygen partial pressures poses potential oxygen toxicity, of which there are two forms: Central Nervous System (CNS) oxygen toxicity and pulmonary oxygen toxicity. As a tec diver, you're concerned with avoiding both.

CNS Oxygen Toxicity. Central Nervous System toxicity results from exposure to PO_2s above 1.4 ata during the working/bottom phase of a dive, and above 1.6 ata during the rest/decompression phase. High exertion, cold water and some drugs (CNS exciters) may make CNS toxicity more likely. The oxygen interacts with various biochemical processes within the body, causing a primary symptom/sign of a convulsion, which as you recall is itself relatively harmless. However, a convulsing diver underwater is likely to lose the mouthpiece and drown, hence the seriousness of the hazard.

Warning signs/symptoms usually do not precede a convulsion, but if they do, they include visual disturbances, ear ringing or sounds, nausea, twitching in facial muscles, irritability and restlessness, and dizziness. Remember VENTID - vision, ears, nausea, twitching, irritability, dizziness.

Managing CNS Oxygen Toxicity. Whether using air, enriched air or oxygen, the primary method for managing CNS toxicity related oxygen exposure is to keep your PO_2 at or less than 1.4 ata (working phase) or 1.6 ata (decompression/safety stop phase). *However, you must accept the risk that, under rare circumstances, CNS oxygen toxicity can occur at PO_2s lower than 1.4/1.6 ata.* Therefore, it's prudent to stay well within oxygen limits.

CNS *toxicity is very unpredictable when a diver exceeds 1.4 - 1.6 ata PO_2*. There's not a clean time/exposure relationship between your PO_2 and the risk of a hit. Furthermore, physiology can cause significant variability — the same diver can have no problems at an excessively high PO_2 for hours one dive, and convulse in minutes at a lower PO_2 in another. High exertion, cold water and some drugs (CNS exciters) may make CNS toxicity more likely. Although your risk diminishes when you drop your PO_2, you can still have a convulsion after ascending or switching to a gas with less oxygen. Therefore, your best safeguard is to stay well within limits — there's generally no real dive time or decompression advantage to pushing them.

Finally, although not available at this writing, it appears that full face masks suitable for practical decompression in tec diving will be available; consider using them — you're far less likely to drown if you should have the misfortune to convulse underwater, but the fortune to be using a full face mask.

Pulmonary Oxygen Toxicity. Pulmonary toxicity results from long term and repeated exposure to PO_2s above .5 ata. It's the lungs' reaction to the elevated oxygen partial pressure and is not immediately life threatening. Signs/symptoms include lung irritation, burning sensation in the chest, coughing, and reduced vital capacity.

In recreational enriched air diving, pulmonary toxicity is highly unlikely. Staying within no stop limits and using EANx blends with 40 percent oxygen and less, you have to dive your brains out to get anywhere near your exposure limits. In tec diving, however, it's another story. Because of your dive depth, because you may use EANx with more than 40 percent oxygen and/or pure oxygen when decompressing, and because your dive duration may go well beyond no stop limits, pulmonary toxicity becomes much more likely, especially when tec diving for several days in a row. Fortunately, it's not difficult to manage your oxygen exposure and avoid pulmonary toxicity.

Managing Pulmonary Oxygen Exposure.

The DSAT Oxygen Exposure Table, which you're familiar with from your PADI Enriched Air Diver course, is one of several variations of the so-called "CNS clock" method for managing oxygen exposure. The "CNS clock" is based on allocating exposure as a percentage of the maximum of the US National Oceanic and Atmospheric Administration (NOAA) oxygen limits. (See the Oxygen Limits Table in the Appendix.)

The method was labeled the "CNS clock" because it was thought, somewhat inaccurately, to manage CNS exposure. Actually, it is useful, but primarily because it manages pulmonary oxygen toxicity — though may have some benefit in reducing CNS risk. You'll build upon what you learned in the Enriched Air Diver course to extend the methodology in Chapter Three.

The DSAT Oxygen Exposure Table, which you're familiar with from your PADI Enriched Air Diver course, is one of several variations of managing oxygen exposure based on allocating exposure as a percentage of the maximum of the US National Oceanic and Atmospheric Administration (NOAA) oxygen limits.

You'll also be learning to use the Repex method for managing pulmonary oxygen toxicity. This method assigns oxygen dose units, called Oxygen Tolerance Units or Oxygen Toxicity Units (OTUs), based on your daily exposures, and your cumulative exposure for multiple days of diving. Although using OTUs and the "CNS clock" at the same time is somewhat redundant, doing so has a good track record and has become the prevailing practice in tec diving. You'll learn more about OTUs, how to determine them and OTU limits in Chapter Three.

Also in Chapter Three, you'll learn three ways by which you track OTUs and the "CNS clock." One is by using formulas and tables (better) to tally your exposure for each dive. Enriched air dive computers also track oxygen exposure automatically (more practical) and desk top decompression software will automatically calculate both "CNS clock" and OTUs (very practical and simplifies dive planning, even with a dive computer.)

Tec Exercise – 1.3

1. An Equivalent Air Depth is a(n) ________________ ______________ you use on __________ tables when using enriched air nitrox with air tables. You find it with a(n) _______________ or by looking it up on a(n) ________________.

2. The maximum recommended PO_2s for technical deep diving are _________ ata for the bottom/working dive phase, and ________ ata for the decompression phase.

3. The maximum depth you can use a gas blend during the working part of a dive is determined by
   - ☐ a. the depth at which it reaches 1.4 ata.
   - ☐ b. the density of the gas.
   - ☐ c. approximately nine variables.
   - ☐ d. the depth at which it reaches 1.6 ata.

4. The maximum depth you can use a gas blend during the decompression part of a dive is determined by
   - ☐ a. the depth at which it reaches 1.4 ata.
   - ☐ b. the density of the gas.
   - ☐ c. approximately nine variables.
   - ☐ d. the depth at which it reaches 1.6 ata.

5. To find your SAC rate you swim underwater and enter your ________________, ________________, and the _______________ _____________ ____________ into the SAC rate formula.

6. (Metric) If your working SAC rate is 19 litres per minute, how much gas supply do you need for 20 minutes at 18 metres? Answer: _____________

6. (Imperial) If your working SAC rate is .68 cubic feet per minute, how much gas supply do you need for 20 minutes at 60 feet? Answer: _____________

7. (Metric). You've estimated you need 2450 litres of gas for a dive. Following the rule of thirds reserve, what's the total volume of that gas you should have? Answer: _______

7. (Imperial). You've estimated you need 94 cubic feet of gas for a dive. Following the rule of thirds reserve, what's the total volume of that gas you should have? Answer: _______

8. (Metric) A 12 litre cylinder has 155 bar in it. How many litres of gas does it hold? _____

8. (Imperial) A 100 cubic foot cylinder, working pressure 2450 psi, has 2200 psi in it. How many cubic feet of gas does it hold?

9. The primary cause of CNS oxygen toxicity is ___________, and the primary cause of pulmonary oxygen toxicity is __________.
   - ☐ a. exposure to PO_2s above 1.4-1.6 ata/long term exposure to PO_2s above .5 ata
   - ☐ b. exposure to PO_2s above .5 ata/long term exposure to PO_2s above 1.4-1.6 ata
   - ☐ c. exposure to PO_2s above .5 ata/long term exposure to PO_2s above .5 ata
   - ☐ d. None of the above.

10. Signs and symptoms of CNS toxicity include (check all that apply):
    - ☐ a. convulsion
    - ☐ b. tunnel vision
    - ☐ c. ear ringing
    - ☐ d. nausea

11. Signs and symptoms of pulmonary toxicity include (check all that apply):
    - ☐ a. lung irritation
    - ☐ b. frequent urination
    - ☐ c. coughing
    - ☐ d. reduced vital capacity

12. The "CNS clock" is based on allocating exposure as a percentage of the NOAA oxygen limits.
    ☐ True ☐ False

13. OTUs are oxygen doses based on your daily exposures and your cumulative exposure for multiple days of diving.
    ☐ True ☐ False

14. The way you determine your OTUs and "CNS clock" is with (check all that apply):
    - ☐ a. formulas.
    - ☐ b. tables.
    - ☐ c. dive computers (track automatically).
    - ☐ d. desk top decompression software.

15. The primary way you avoid CNS oxygen toxicity is by
    - ☐ a. limiting your PO_2 to 1.4 ata (working phase) and 1.6 ata (deco phase).
    - ☐ b. tracking your "CNS clock" exposure.
    - ☐ c. tracking your OTUs.
    - ☐ d. All of the above.

Check it out.
1. adjusted depth, air, formula, table. 2. 1.4 ata/1.6 ata. 3. a. 4. d. 5. depth, time, pressure you used. 6. (Metric) 1064 litres, (Imperial) 38 cubic feet. 7. (Metric) 3675 litres, (Imperial) 141 cubic feet. 8. (Metric) 1860 litres 8. (Imperial) 89.8 cubic feet. 9. a. 10. a,b,c,d. 11. a,c, d. 12. True. 13. True. 14. a,b,c,d. 15. a.

Team Diving I

The Team Concept

One of the first things you learned as a recreational diver is that you dive with a buddy. And as you recall, you do this for reasons that include safety advantages, practicality and to have more fun.

Tec diving takes the buddy system to the next emphasis level with the *team diving* concept. What team diving means is that you embrace and apply the philosophy that tec divers work as a team, integrating each team member's needs and efforts during predive checks, meeting equipment requirements, planning and executing the dive, and other details, while pursuing a common goal. As a team, you treat the dive as a mission with specific purpose the team pursues together with a common goal, rather than just as an "underwater visit."

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is meant by "team diving"?
2. What are four benefits of team diving?
3. What are your responsibilities as a team member when technical diving?
4. What is the rule regarding aborting a technical dive?

ONE

Team diving integrates each team member's needs and efforts while pursuing a common goal. As a team, you treat the dive as a mission with specific purpose the team pursues together with a common goal, rather than just as an "underwater visit."

Team Diving Benefits

There are several reasons why technical diving embraces the team diving concept so closely. Each of the following benefits have proved themselves again and again:

1. Team diving has a higher likelihood of mission success based on detailed dive planning. When several people focus their efforts on a common goal, it's more likely to get done than if the same people dive together with diffuse purpose. The more effort and planning that goes into the single mission, the higher the probability of success.

2. Team diving fosters preparedness and resources for handling complex emergencies. One distinct aspect of tec diving is that handling problems can be far more complicated than in recreational diving. A unified, team approach to problem prevention and management brings maximum resources to bear when trouble rears its head — and a higher likelihood of a happy outcome.

3. Team diving reduces accidents by providing a "back up brain" for each other during predive checks and throughout the dive. You can have multiple regulators, multiple cylinders, multiple computers, multiple dive tables and multiple almost everything, but you still only have one brain. The fact is, most dive accidents don't result from spontaneous bad luck, but directly or indirectly from human error. By diving in a team, you and your team mates agree on plans and procedures, and remind each other of these by diving closely together. When everyone does everything the same way at the same time, the probability of an omission or mistake by one team member goes way down.

Until you've experienced it, you can't understand how common goals and purpose will bring you and your fellow team mates together in spirit.

4. Team diving provides the camaraderie that comes from facing a challenge together. Until you've experienced it, you can't understand how common goals and purpose will bring you and your fellow team mates together in spirit. However, by the end of the DSAT Tec Deep Diver or Apprentice Tec Diver course you will — in fact, it's one of your goals as a student. When you meet with your class mates next, start thinking of them as team mates. To an extent, you'll be trusting your life to some of them, and they to you.

Now there's something to think about.

Team Size

You need to dive as part of a team, but a "team" can be two divers (you and another diver) or 10 to 20 divers working on a project. There are no hard "rules" or "standards" regarding team size, but typically two to four divers compose a dive team (this doesn't count support divers, when present). Large teams (typically five or more divers) usually divide into subteams to make things more manageable. The divers, the dive objective and other objectives may all influence what the appropriate team size will be.

Many tec divers regard three as the optimum team size because it's small enough for the team mates to easily work together, yet may simplify managing some emergencies because it provides two divers to assist one with a problem. Nonetheless, you'll find that teams of two, or four or more, are common and function quite effectively.

Your Responsibilities as a Team Member

Being part of a team carries responsibilities, and that's particularly true in tec diving. Meeting each of these is what makes your team possible, and what brings the benefits a team provides:

1. *Be self sufficient, even in an emergency.* You plan your dives so you can respond to emergencies independently. Your team mates give you additional resources and may be your Plan B if your independent Plan A response falls short, but relying on your team mates should not be your primary emergency response. Why? Because when each team member stands independently, each can lend strength and resources if things go awry. If team members rely on each other from the start, the team's taxing this reserve from the start.

2. *Don't let the team carry you beyond your limits*. You owe it to yourself and your team mates to let them know where you limits lie. A strong team can sometimes carry you well past them — but at that point you're no longer self sufficient, and you undermine the team's ability to respond if trouble arises. A constructive team spirit is to help less experienced divers *extend* their limits so they grow, but not bust limits and take them where they're not capable of taking care of themselves.

3. *Watch your team mates as closely as you watch yourself.* After you check your gear, check their gear. After you confirm what gas you're breathing, confirm what gas they're breathing. This is the "back up brain" function. If you're not sure about what a team mate's doing, point it out and ask — don't assume your mate knows more than you. Remember, *human error* is the number one cause of dive accidents.

4. *When necessary, surrender your individual preferences to team needs.* As you'll learn, for example, there's tremendous advantage to team members diving with the same (or compatible) gases. You may prefer something different on a given dive, but team unity reduces task loading and simplifies handling emergencies — a major benefit that you don't want to eliminate. If you feel a team choice compromises safety (which should be very rare) and you can't reach a consensus, then it's your responsibility to respectfully decline to dive.

5. *Do not exert peer pressure and do not succumb to peer pressure.* All team members, including you, need to be confident about their ability to make the dive. If something doesn't sound reasonable, or sounds beyond what you can reasonably handle at your experience and training level, *speak up*! Rest assured, your team mates will *appreciate* your candor and adjust the dive plan accordingly. (By the way, if you ever feel peer pressured so strongly that it's hard to confront — it can happen — there's a face-saving way out. Simply say, "I can't equalize." After all, who but you really knows?)

Eliminating peer pressure is so important in tec diving, that there's actually a special safety rule for it. It originated in cave diving, and today the entire technical diving community embraces it: **Any diver can abort any dive at any time for any reason.**

Practice and honor this rule.

Tec Exercise – 1.4

Tec Exercise 1-4

1. Team diving means that you apply the philosophy that tec divers work as a team, __________ each team member's needs and efforts while pursuing a common __________.
2. Benefits of team diving include (check all that apply):
   - ☐ a. higher likelihood of mission success
   - ☐ b. preparedness and resources for handling complex emergencies
   - ☐ c. accident reduction by providing a "back up brain"
   - ☐ d. the camaraderie that comes from facing a challenge together
3. Your responsibilities as a team member include (check all that apply):
   - ☐ a. Be self sufficient, even in an emergency.
   - ☐ b. Don't let the team carry you beyond your limits.
   - ☐ c. Watch your team mates as closely as you watch yourself.
   - ☐ d. Do not exert peer pressure and do not succumb to peer pressure.
4. Any diver can _______ any ________ at any _______ for any ________.

Check it out:
1. integrating, goal. 2. a,b,c,d. 3. a,b,c,d. 4. abort, dive, time, reason.

Techniques and Procedures I

Okay, it's time to start looking at the techniques and procedures you'll need as a Tec Deep Diver and Apprentice Tec Diver, and that you'll be learning and applying during the course Practical Applications and Training Dives. You'll start with predive checks, followed by an overview of buoyancy control and weighting techniques. Then you'll learn about descent checks.

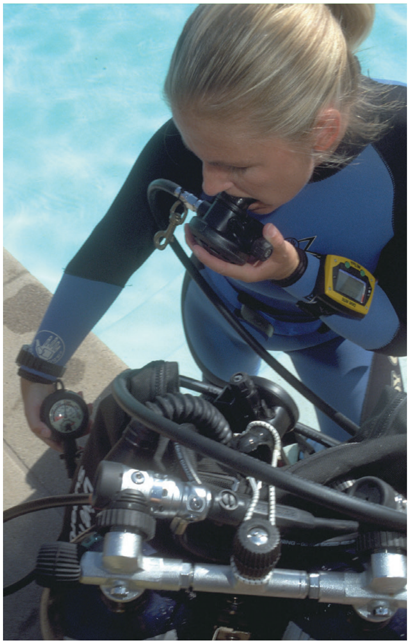
Predive Checks

In your Open Water Diver course, you learned that before each dive, you make a predive safety check to be sure your gear's in order before hitting the water. You do the same thing in tec diving, but as you may imagine, the check's more extensive and takes more time — appropriately so.

You'll actually learn two predive checklists in later chapters that give you details; for now, here are the general elements that you and your team mates cover:

- All equipment and back up equipment — set up and function.
- Gas supplies — contents, quantities and proper marking.
- Decompression status monitoring — computers/tables, back ups and compatibility.
- Equipment rigging and configuration — all secure, properly located and routed, all team members know where to find each other's gear.

Get in the habit of using a preprinted checklist, such as on the TecRec Dive Planning Checklist.



A tec dive begins with predive planning and predive checks — something you'll practice many times during this course.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What general elements does a technical diving predive check cover?
2. How do you determine the minimum weight you need for a technical deep dive?
3. What is the primary hazard of diving negatively buoyant, and how do you manage this hazard?
4. What is the primary hazard of excessive positive buoyancy, and how do you manage this hazard?
5. How do you determine the minimum buoyancy you need for a technical deep dive?
6. What are the techniques for using a dry suit and BCD?
7. What is the technique for using a redundant (double) BCD?
8. What is a descent check and when do you do it?

Weighting and Buoyancy

You're about to take what you learned about proper weighting and buoyancy in recreational diving and, for the most part, heave it out the window. Tec diving's a different animal and different principles apply.

Determining Minimum Weight. Looking at the mega-kit a tec diver wears, you might ask, "*Minimum* weight? That doesn't even look like an issue."

But surprisingly, it can be. Although you may be quite negatively buoyant at the start of a dive with no lead, consider that you carry a huge gas volume compared to recreational diving. On some dives, were you to consume almost all your gas, you'd be 7 kg/15 lbs *or more* lighter than when you started. At the end of the dive you might find yourself unable to stay down to make a decompression or safety stop.

Therefore, you normally want to weight yourself for the worst-case

You normally want to weight yourself for the worst-case scenario, which would be an emergency situation of having to maintain a decompression/safety stop at 5 metres/15 feet with nearly empty doubles. Weight yourself so you float at eye level, or slightly sink, with near empty doubles and without stage/deco cylinders. (With heavy cylinders, you may still be negatively buoyant — that's acceptable.)

scenario, which would be an emergency situation of having to maintain a decompression/safety stop at 5 metres/15 feet with nearly empty doubles. To find this, put on all your gear (but no stage/deco cylinders) and perform a conventional buoyancy check with 35 bar/500 psi or less in your doubles (or high capacity single if using one). Weight yourself so you float at eye level, or slightly sink, and you've set your minimum weight for that gear configuration.

If you're wearing heavier doubles, such as high capacity steel cylinders, even with only about 35 bar/500 psi, you may still be negatively buoyant. This is acceptable in tec diving, and naturally, it means you don't need any more weight.

Hazards of Negative and Positive Buoyancy. If you're neutrally or negatively buoyant with near-empty cylinders, obviously you're going to be quite negative when they're filled, and heavier and more negative still if you're using additional stage/decompression cylinders. In this case, you're BCD dependent — that is, you need your BCD to be able to ascend.

The primary hazard of diving negatively buoyant is having a BCD failure that makes it effectively impossible to ascend. As you learned earlier, you manage this hazard by having more than one way of regaining buoyancy control. You may have a double bladder BCD (double wings), or a BCD and a dry suit. However, keep in mind that for the heaviest diving, a dry suit may not supply sufficient buoyancy (consult the manufacturer if necessary) and you may still need a redundant BCD. Even if it provides enough buoyancy, you have to be concerned with the stress on your neck and wrist seals and the zipper, which could fail under the stress. Excessive pressure on the neck can cause unconsciousness due to the carotid sinus reflex.

If you're excessively positively buoyant (underweighted or losing your weights), the hazard is that you might not be able to make required decompression stops, and/or have an uncontrolled ascent, leading to very high DCI risk. You manage this risk by checking your weight as you just learned (with near empty cylinders), and by rigging your weights so you won't lose them easily (such as by using two buckles on your weight belt).

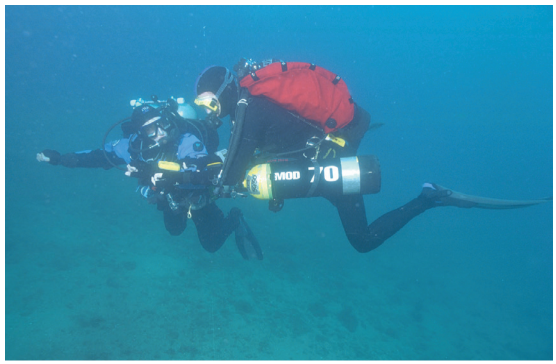
The minimum buoyancy you need is sufficient buoyancy to float with your head comfortably above the surface while wearing full doubles and stage/decompression tanks.

Determining Minimum Buoyancy. Given that you may be quite negatively buoyant at the start of a tec dive, having enough buoyancy is a real issue. The minimum buoyancy you need is sufficient buoyancy to float with your head comfortably above the surface while wearing full doubles and stage/decompression tanks. You choose your BCD lift capacity with this in mind, and confirm by checking in water shallow enough to stand in.

In determining minimum buoyancy, a reminder: you *don't* use both bladders in a double BCD at the same time. They don't double your lift. You use them one at a time.

Buoyancy Control Underwater

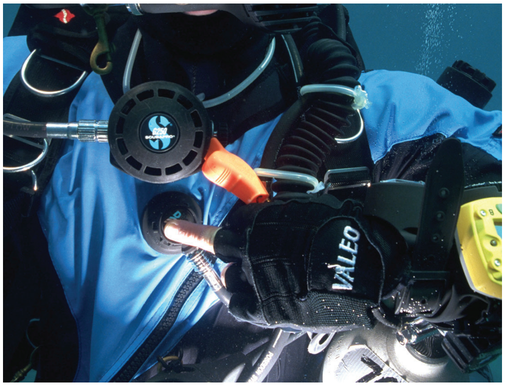
Controlling your buoyancy underwater on a tec dive differs from on a recreational dive in many respects. If you're diving in a wet suit, you'll use your BCD. Okay, okay, duh, but one difference is that while you should have relatively little air in your BCD while underwater on a recreational dive, when tec diving you'll usually have a good bit of gas in it to offset the weight.



When tec diving you'll usually have a good bit of gas in your BCD to offset the weight of all your gear.

If you're diving dry on a recreational dive, you control buoyancy exclusively with your dry suit while underwater (except in an emergency). Not so on a tec dive because that would be way too much gas in your dry suit. Instead, you will add and release air from both your BCD and your dry suit, putting just enough in your suit to offset suit squeeze. This is a bit more task loading than controlling just one device.

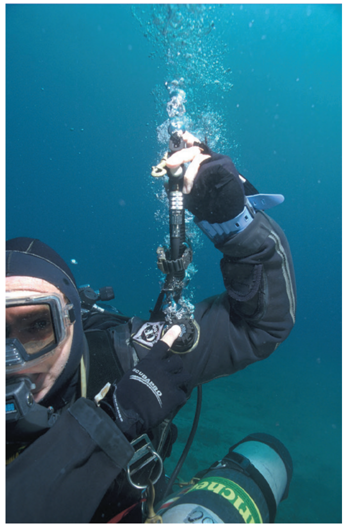
During descents, one technique that helps is to hold your BCD inflator over your dry suit inflator so that you can add air to both with the same hand. This leaves your right hand free to equalize your ears, follow a line, etc. Whether diving wet or dry, begin adding gas as soon as you start down and keep adding in bursts as you go. Because of your weight, negative buoyancy mounts rapidly as pressure compresses your suit and the air in your



When descending in a dry suit, hold the BCD inflator over the suit inflator. This allows you to inflate both with one hand — the BCD with your thumb and forefinger, and the dry suit with your middle finger. (No impolite gestures intended!)

BCD. If you let this get ahead of you, you may find it hard to regain control of your descent. (Don't worry — you'll practice this in moderately shallow water until you get the hang of it.)

If diving dry, on ascent raise your left shoulder and suit exhaust valve, with the valve set to release expanding gas automatically. That way, as you come up you only have to release gas from your BCD manually, while the suit takes care of itself. Diving wet, you'll just have the BCD, of course, but you may be surprised at how much more gas you have to release compared to a recreational dive.



As you ascend, vent air from both your dry suit and BCD. This differs from recreational dives in a dry suit, during which you control your buoyancy only using the dry suit underwater.

When diving with redundant BCDs (double wings), as you've learned, you don't use the back up unless the primary fails. One reason for this is that if you were to inflate both simultaneously, the stress on the outer bag that holds both bladders could rip it, causing the entire system to fail. (Oops.) This is particularly possible during ascent, when both bladders could burst the outer bag before their over pressure valves opened.

You use a descent check to look for gas leaks, to confirm gear operation and to confirm each other's kit. It takes only a moment, but gives the team a pause to make sure everything's in order before forging onward.

Descent Checks

Besides predive checks, technical divers check each other after they get into the water. Depending upon dive requirements, they may do this just under the surface, or by pausing in the 5 metre/15 foot to 6 metre/20 foot range, or at the depth where you stage your first deco cylinder, or a combination of these. You use a descent check to look for gas leaks, to confirm gear operation and to confirm each other's kit. It takes only a moment, but gives the team a pause to make sure everything's in order before forging onward.

You'll learn descent check details later in the course. For now and in your first training dive, practice by looking over your team mate(s) for anything that might be out of sorts.

ONE

Tec Exercise – 1.5

1. The general elements of a predive check include (check all that apply):
   - ☐ a. equipment set up and function
   - ☐ b. gas supplies — contents, quantities and marking
   - ☐ c. equipment rigging and configuration
   - ☐ d. dive conditions

2. If you're properly weighted for a tec dive, generally you should float at eye level (or be negative) with
   - ☐ a. full back cylinders and full stage/deco bottles.
   - ☐ b. full back cylinders and nearly empty stage/deco bottles.
   - ☐ c. nearly empty back cylinders and full stage/deco bottles.
   - ☐ d. nearly empty back cylinders and no stage/deco bottles.

3. The primary hazard of diving negatively buoyant is have a _________ failure that makes it effectively impossible to ____________.

4. The primary hazard of excess positive buoyancy is that you might not be able to _______ _______ _________ _________, and/or have an uncontrolled _________, resulting in a high risk of __________.

5. The minimum buoyancy you need is sufficient buoyancy to float with your ________ comfortably above the surface while wearing _________ ________ and _____/_______ _______.

6. When tec diving in a dry suit, you only add gas to the suit, and not the BCD, to control buoyancy underwater
   ☐ True ☐ False

7. You would use both bladders at the same time in a redundant (double wing) BCD when (check all that apply)
   - ☐ a. at the surface.
   - ☐ b. one bladder doesn't provide enough buoyancy alone.
   - ☐ c. carrying stage/deco cylinders.
   - ☐ d. Never.

8. A descent check is normally made just below the surface, or in the 5 metre/15 foot to 6 metre/20 foot range, to look for gas leaks, to confirm gear operation and to confirm each other's rigging.
   ☐ True ☐ False

Check it out.
1. a,b,c. d is not correct because evaluating dive conditions is part of predive planning and preparation, not the check. 2. d 3. BCD, ascend. 4. make required decompression stops, ascent, DCI. 5. head, full doubles, stage/decompression tanks. 6. False. In tec diving, you will usually need to add gas to both the dry suit and the BCD. 7. d. 8. True.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the emergency procedures for using the long hose second stage to handle an out of gas emergency?
2. What are the emergency procedures for a massive regulator free flow at depth?
3. What are the emergency procedures for a damaged doubles manifold at depth?
4. What are "S-drills" and when do you do them?

Emergency Procedures I

In the last section you learned some of the procedures you'll use routinely as a tec diver. In this section, you begin learning about the many emergency procedures tec divers must master. They're similar to, but not always identical to, recreational methods for handling the same type emergency. One reason for this is that tec diving emergency procedures arise from the fact that ascending directly to the surface is usually not an option. You will practice the procedures covered here during Training Dive One, and continue to practice them throughout the course. The idea is to be able to perform emergency skills quickly, confidentially and automatically.

The tec diving emergency procedures you'll be learning arise from the fact that ascending directly to the surface is usually not an option.

No Gas Emergency – Long Hose Gas Sharing

Gas sharing with your long hose is similar to alternate air source air sharing in recreational diving. However, while this is a primary means for handling a gas emergency in recreational diving, in technical diving it is actually a secondary option because the victim should always have another breathing source available. Sharing with a team mate only comes into play when the secondary breathing source doesn't work either, or there's some delay in deploying it.

You might need to share gas with your long hose for several reasons. The victim may have planned the gas requirements poorly, or failed to execute the gas management plan properly. A runaway regulator or manifold leak could have drained a substantial portion of the supply, and the victim exhausts the remainder with the secondary regulator before the dive ends. There could also be an unplanned delay in ending the dive, taxing the gas supplies available. Finally, in a no-gas emergency, sharing with your long hose is the most immediate way you can assist a team mate. Even if team mates have another breathing source (as they should), your long hose solves the immediate need for gas while you sort out the problem and the options.

The procedure for using the long hose is:

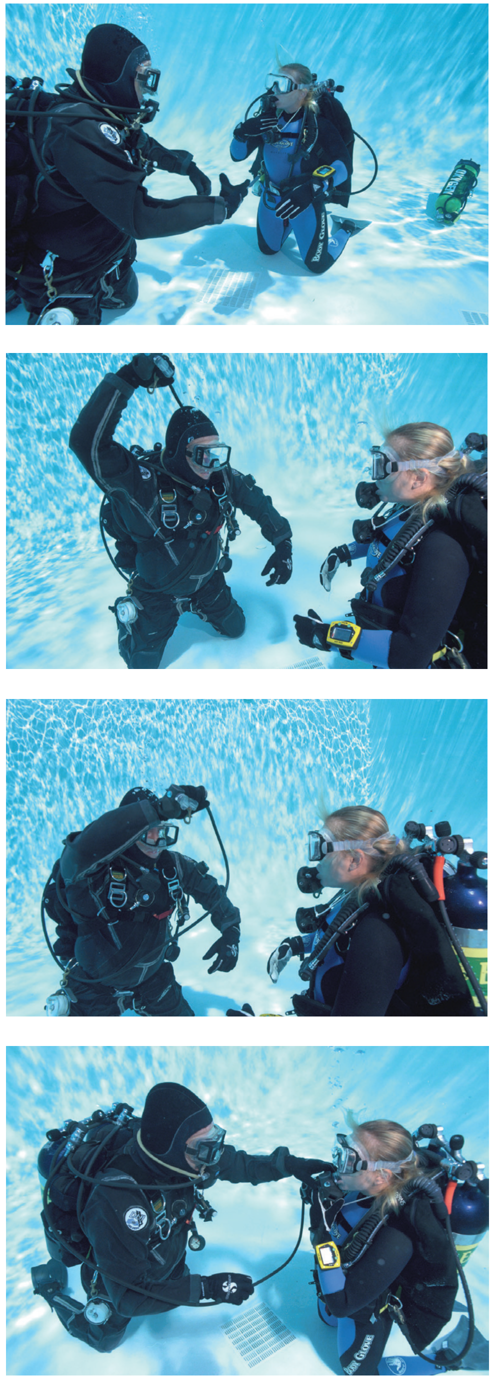
1. Out of gas diver (receiver) signals "out of gas."
2. The donor passes the second stage from the mouth to the receiver, unlooping the hose from over the head with an arm twist while doing so (with practice, easier than it sounds — no worries). The donor then switches to the short hose secondary hanging around the neck. If the long hose is clipped off (while breathing from a stage/deco cylinder), the donor jerks it off the breakaway clip and stays on the stage/deco cylinder.
3. Abort the dive. If the receiver must stay on the long hose, the hose length provides versatility to maneuver as necessary for the specific situation. If you're still in a no stop situation, you ascend to the safety stop and/or surface. On a decompression dive, you ascend to where the receiver can switch to a decompression cylinder.

Regulator Free Flow – Gas Shut Down

As you recall, modern regulators usually free flow if they fail. A minor free flow is not usually an urgent situation (though you want to end the dive because a small leak can get worse), but a runaway regulator will quickly deplete your precious gas.

A common reason for a free flow is poor maintenance, however, a dislodged first stage can also cause a runaway gas leak between the valve and the regulator. This usually results from impact, and is less likely with DIN regulators. Another cause in cold water diving is regulator freezing.

If this happens you'll have a lot of gas rush from the second stage, or from where the first stage meets the valve.



When a team mate signals "out of gas," you deploy the long hose second stage by unlooping it from around your head in one motion. Switch to your short hose regulator while your team mate uses the long hose.

You should be able to independently close any of the valves on your manifold. If necessary, loosen your waist back, undo or loosen the crotch strap and lift the cylinders with your other hand.

Follow this procedure:

1. Breathe from the unaffected regulator.

2. Reach behind you and close the valve to the free flowing one. Having the valves all the way open (not closed back a partial turn) reduces confusion about which way to turn — the only direction it goes is closed. After you close it, everything gets quiet fast.

You should be able to do this independently. If necessary, loosen your waist strap, undo/loosen the crotch strap and lift the cylinders with your other hand.

3. Abort the dive.

In an actual emergency, your team mates may assist. During the Training Dives, you'll practice helping each other and shutting down the valves independently, with the emphasis on doing it by yourself.

Cylinder Isolation – Manifold Failure

If your doubles manifold fails, you have a leak that you can't shut down. This can happen due to severe impact, improper assembly, gross over filling, poor maintenance, or a weakened burst disk. In all cases, your gas is going bye-bye fast, usually with a huge noise that sounds like a tornado trying to sneak up on you, and a cloud of bubbles. Follow this procedure:

1. Reach back and close the isolator valve in the manifold's center. This will preserve the gas remaining on the unaffected side. This is similar to a regulator valve shutdown, and again, it helps to have the valve all the way open so there's no question about which way to turn. After you close it, the gas will continue to rush from the affected side until it's gone. Don't reopen the isolator trying to make it stop —you can't.

2. Try to determine which side is leaking. Lean back and look up to see if you can tell where the bubbles are coming from. Look at your SPG — if it's dropping like crazy, the leak's on the left. If not, it's on the right. A team mate will probably be able to tell better than you.

3. As you abort the dive, breathe from the leaking side until the gas is gone before switching to the conserved side.

Single cylinders obviously don't have an isolator valve, and in some areas you may have difficulty finding doubles with isolator valves.

If you have an unidentified gas leak behind your head that you cannot immediately solve, close the isolator immediately until you sort out the problem. If it's not the manifold (such as a dislodged first stage), you can reopen the isolator after correcting the problem.

As with regulator valve shutdowns, team mates may help each other, but your practice will focus on doing it yourself for self sufficiency.

A note, by the way, for overhead environment diving (if you're qualified or take it up in the future): your left manifold valve can roll shut if it bumps the ceiling repeatedly while you swim. Check it periodically to be sure it's all the way open, and avoid ceiling contact. (You learn more about these during courses for these activities.)

An S-drill is a safety drill in which you and your team mates practice long hose gas sharing while swimming, valve shut downs and other emergency procedures.

S-drills

Tec divers periodically practice "S-drills" to stay prepared for emergencies ("S" for "safety," of course. Told you divers shorten everything.) An S-drill is a safety drill in which you and your team mates practice long hose gas sharing while swimming, valve shut downs and other emergency procedures. You normally do this in shallow water before a dive, though you may practice them during safety/decompression stops (passes the time), or make a separate dive just for the practice.

You perform an S-drill when:

- diving with new team mates for the first time.
- you want to practice and refresh your skills.
- your team needs to modify any emergency procedures to address specific dive requirements.
- you and team mates need to confirm that you're following the same procedures.

Tec Exercise – 1.6

1. When sharing gas, the regulator you pass to the receiver is
   - ☐ a. whichever one is handy.
   - ☐ b. the long hose, which is in your mouth.
   - ☐ c. the long hose, which is hanging around your neck.
   - ☐ d. the short hose, which is hanging around your neck.
2. In the event of a massive regulator free flow, you should (check all that apply):
   - ☐ a. switch to the unaffected regulator.
   - ☐ b. breathe from your team mate's long hose.
   - ☐ c. shut down the valve to the affected regulator.
   - ☐ d. close the isolator valve.
3. In the event of a gas leak from a damaged doubles manifold, you should (check all that apply):
   - ☐ a. breathe from the regulator on the affected side.
   - ☐ b. breathe from your team mate's long hose.
   - ☐ c. shut down the valve to the affected regulator.
   - ☐ d. close the isolator valve.
4. You perform an S-drill when (check all that apply):
   - ☐ a. diving with new team mates for the first time.
   - ☐ b. you want to practice and refresh your skills.
   - ☐ c. your team needs to modify any emergency procedures to address specific dive requirements.
   - ☐ d. you and your team mates need to confirm that you're following the same procedures.

Check it out:
1. b. 2. a, c. b is not correct because you still have gas and a functioning regulator. c is not correct because closing the isolator does not stop gas escaping the free flowing regulator. 3. a, d. b is not correct because you still have gas and two functioning regulators. c is not correct because a regulator is not the problem. 4. a,b,c,d.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What does Hick's Law tell us about reaction times in an emergency?
2. What is the KISS principle, and how does it relate to technical diving?
3. What is the over-riding mission of all technical dives?
4. Why does "cutting corners" lead to technical diving accidents?

Thinking Like a Technical Diver I

Becoming a capable tec diver means learning to think like one. Learning a way of thinking may sound like a tall order, but actually, you do it all it the time, and you did when you became a recreational diver. It means that you learn the principles that influence how you will plan, execute and learn from every dive you make.

There may be things that you're learning now, in this course that you understand *when* and *how* to apply, but not why tec divers are so adamant and inflexible about them. As you master thinking like a technical diver, suddenly you'll discover you understand. You'll find that you innately understand why tec procedures are what they are, why tec divers do what they do and it will seem obvious. At that point, you will be a Jedi . . . well, something like that.

Hick's Law and Establishing Emergency Procedures

Question: For a given emergency situation, is it better to have lots of possible ways to handle it, or just one or two? Many people would say "lots of possible ways," instinctively judging based it on the idea that the more options you have, the more likely one will work. Therefore, more must be better. Logical. But wrong.

Hick's Law (1952) says:

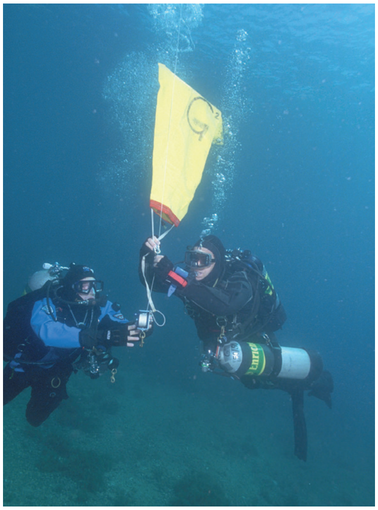
> **$RT = K \log_2 (N + 1)$**
>
> **where**
>
> **RT = reaction time, K = a constant and N = the number of possible choices**

If that doesn't settle it, nothing will.

Okay, okay, everyone else has to have it explained, too. In simple terms, Hick's Law says that *the more ways you have to respond to an emergency, the longer it takes to react*. It also says that *the reaction time increases substantially for each added choice.*

Therefore, having lots of ways to handle the same thing reduces how fast you'll handle it. According to Hick's Law, what you want is the fewest procedural choices possible — only as many as necessary to cover all reasonably likely contingencies. Your reaction speed increases because you spend less time choosing what to do. Aviation, space flight, anaesthesia, emergency medicine, and the nuclear power industry among others have all proven this; they have found the most effective emergency responses arise from relatively few, standardized and practiced procedures.

You could really consider Hick's Law a corollary of technical diving's ultimate principle:



According to Hick's Law, what you want is the fewest procedural choices possible — only as many as necessary to cover all reasonably likely contingencies. Your reaction speed increases because you spend less time choosing what to do.

The KISS Principle

If you ever doubt what you should do in any tec diving situation, chances are you won't go wrong if you go back to the KISS principle. KISS (polite version) stands for Keep It Super Simple. Or in another manner of speaking, the simplest way to accomplish anything is usually the best way.

Technical diving creates high mental and physical demands. Complexity adds to these demands, so that the more complicated the tasks required, the greater the likelihood of failure. The KISS principle teaches you to break complex tasks into several simple tasks to have several divers handle, to have several dive teams handle, or to handle over two or three dives — or a combination of these. The KISS principle challenges you to look at every part of a dive plan and procedure and question the complex. Does it really have to be this difficult? What can you do to simplify it?

The KISS principle also explains why the tec diving community has evolved a fairly standardized basic rig and emergency procedures. Standardizing reduces variables and simplifies procedures, which conforms with Hick's Law to reduce reaction time.

Maybe now you're starting to understand why tec divers think like they do.

The Mission

Technical dives tend to be mission oriented — something you'll spend more time on in later chapters. But no matter what you plan to accomplish, every technical dive has an over-riding mission that you never compromise and that supersedes *everything* else: To return with all your team mates unharmed.

That may seem obvious, but as you now know, most dive accidents result directly or indirectly from human error — and one of the most common avoidable causes of technical diving accidents is the error of *compromising safety*.

Never Compromise Safety. Recall that compared to recreational diving, technical diving accidents arise from relatively short error chains. You can't cut corners prepping your gear, or planning and executing your dive because doing so greatly increases the chance of an accident.

Look at an example. Suppose a recreational diver goes down using a dive computer, but (despite recommendations) neglects to take a back up depth gauge, timer and tables. What's the risk if the computer fails? Not that high because were it to happen, the diver is still likely to be within no stop limits, so the diver ascends, makes a long safety stop and gets out of the water.

What about a tec diver who dives without back up tables and gauges? This diver could end up paralyzed for life because a computer failure might mean no way for the diver to determine the required

decompression. If circumstances separate the diver from the rest of the team, or create a substantial difference in decompression requirements — not entirely unlikely — that diver's in a world of hurt.

It's sometimes easy to rationalize "just this once" when faced with a seemingly minor problem and missing the dive because of it. But prudent tec divers remember that "just this once" is the number of failures you need without a contingency to get hurt or killed. Thinking like a tec diver means following *all* safety guidelines every time. It means you never compromise safety for convenience, even if it means missing what would otherwise be a great dive.

If you're ever tempted to cut corners and compromise safety so you can make a dive, ask yourself this: "What will I find, see or do on this dive that would be worth dying for?"

Thinking like a tec diver means following all safety guidelines every time. It means you never compromise safety for convenience, even if it means missing what would otherwise be a great dive. If you're ever tempted to cut corners and compromise safety so you can make a dive, ask yourself this: "What will I find, see or do on this dive that would be worth dying for?"

Tec Exercise – 1.7

1. Hick's Law tells us that (check all that apply):
   - ☐ a. the more ways you have to respond to an emergency, the better.
   - ☐ b. the more response choices you have, the slower your reaction time.
   - ☐ c. you want the fewest response possible choices to cover all reasonable possibilities.
   - ☐ d. None of the above.

2. KISS stands for ___________ ________ ___________, __________. That is, the ____________ way to accomplish anything is the best way.

3. The overriding mission on all dives is to ________ __________ _______ ________ ________ _________ _________.

4. "Cutting corners" can lead to technical diving accidents
   - ☐ a. because it doesn't save any time.
   - ☐ b. because in tec diving, accidents arise from relatively short error chains.
   - ☐ c. only rarely.
   - ☐ d. None of the above.

Check it out:
1. b, c. 2. Keep It Super Simple, simplest. 3. return with all your team mates unharmed. 4. b.

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working within your assigned team, rig your gear so that the equipment of all team members conforms with the standardized technical rig previously learned, and with any environment-specific requirements provided by the instructor.

Preview: Practical Application One

Practical Application One develops your skills in gear rigging, and begins establishing team diving principles — team *thinking* and team *spirit*. Your instructor will assign teams and have teams work together to configure their rigs according to the standardized technical rig methods and principles you've learned, with specific adaptations and requirements to meet local environmental requirements.

Working as a team, refer back to the Equipment I section, and any example rigs your instructor has on display. Your goal is that everyone on your team has a rig set up so that it satisfies the diver, the team and the instructor.

Preview: Training Dive One

Performance Objectives

To successfully complete this training dive, the you will be able to:

1. Working in a team, assemble and inspect the basic technical diving rig following the previously described rigging philosophy and to meet individual/environmental needs.
2. Demonstrate how to determine the proper weight required for the dive.
3. Demonstrate neutral buoyancy while wearing the basic technical dive rig underwater in water too deep in which to stand by hovering for 1 minute without sculling or kicking.
4. Within 30 seconds, independently close the tank valve to a regulator that is experiencing a simulated freeflow.
5. Assist a team mate by closing the correct valve to a regulator that is experiencing a simulated free flow.
6. Within 30 seconds, independently close the isolator tank valve in response to a simulated manifold leak. (Simulated closing is permitted if performing the skill with a high capacity single.)
7. Respond to a simulated out of gas emergency by signaling a team mate, switching to the team mate's long hose second stage, then swimming 30 metres/100 feet using the long hose regulator and maintaining contact with the team mate.
8. Respond to a team mate's simulated out of gas emergency by, on signal, providing the team mate with the long hose second stage, switching to the short hose secondary, then swimming 30 metres/100 feet as the team mate uses the long hose regulator, maintaining contact.

Predive briefing and gearing up

Training Dive One

- Entry
- Weight Check
- Descent
- Descent check
- Neutral buoyancy — hovering for 1 minute, no sculling or kicking
- Regulator free flow — valve shutdown independently, within 30 seconds
- Regulator free flow — team mate assist
- Manifold leak — isolator shutdown independently within 30 seconds
- Manifold leak — team mate assists
- Out of gas — use long hose as receiver, swim horizontally 30 m/100 ft
- Out of gas — use long hose as donor, swim horizontally 30 m/100 ft
- Free time for practice and experience
- Ascent
- Recheck weight with near-empty cylinders
- Exit

Post Dive

- Performance review
- Disassemble and stow equipment
- Log dive for instructor signature
- Assignments

KNOWLEDGE Review – Chapter One

ONE

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. Define "recreational diving," "technical diving" and explain what is not technical diving.

2. List six general risks and hazards that technical diving presents that either don't exit or aren't as severe in recreational diving.

   1. ____.
   2. ____.
   3. ____.
   4. ____.
   5. ____.
   6. ____.

3. What single statement sums up the difference between recreational and technical diving?

4. What are the limits of your training as a Tec Deep Diver or an Apprentice Tec Diver?

   Tec Deep Diver:

Apprentice Tec Diver:

5. What are six characteristics of a responsible technical diver?

   1. ____.
   2. ____.
   3. ____.
   4. ____.
   5. ____.
   6. ____.

6. What should you do if you can't or won't accept the risks and responsibilities demanded by technical diving?

7. What is meant by "standardized technical rigging"? Why do you need to apply it?

ONE

8. Describe the proper types, number, location and configuration within your rig of the following equipment components and as to how your gear will look when worn:

   Manifold:

   Right regulator and accessories

   Left regulator

   BCD and harness

   Instruments

   Cutting tools

   Pockets and clips

9. List the three types of dive computer you can use for technical deep diving with air and enriched air, along with the advantages and disadvantages of each.

10. What are the recommended maximum oxygen partial pressures for technical deep diving?

11. What are the maximum working depths and decompression depths for EANx63?

12. (***Metric***) If your SAC rate is 24 litres per minute, how much gas volume do you need for 20 minutes at 30 metres? What would your total volume be with a reserve based on the rule of thirds?

12. (***Imperial***) If your SAC rate is .8 cubic feet per minute, how much gas volume do you need for 20 minutes at 90 feet? What would your total volume be with a reserve based on the rule of thirds?

13. What are the signs and symptoms of CNS oxygen toxicity, and what's the primary way you avoid it?

14. What are the signs and symptoms of pulmonary oxygen toxicity, and what's the primary way you avoid it?

15. List your responsibilities as a team member when technical diving.

16. What is the rule regarding aborting a technical dive?

17. What is the primary hazard of diving negatively buoyant, and how do you manage this hazard?

18. What is the primary hazard of excessive positive buoyancy, and how do you manage this hazard?

19. Describe how to find the minimum weight and the minimum buoyancy you need for a technical deep dive.

20. How does a technical dive in a dry suit differ from a recreational dive in a dry suit? What's the recommended number of recreational dives in a dry suit that you should have before technical diving in one?

21. Describe the procedure for sharing gas with your long hose.

22. What are the emergency procedures for a massive regulator free flow at depth?

ONE

23. What are the emergency procedures for a damaged doubles manifold at depth?

24. What is the over-riding mission of all technical dives?

25. How and why does “cutting corners” lead to accidents in technical diving?

Student Diver statement: I’ve reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date __________

TWO

Plans must be simple and flexible. Actually they only form a datum plane from which you build as necessity directs or opportunity offers. They should be made by the people who are going to execute them.

— US Army General **George S. Patton Jr.**
1885-1945

Chapter TWO: The Framework

Chapter One established the foundation you need as a Tec Deep Diver or Apprentice Tec Diver. Chapter Two is the framework standing on that foundation; it takes what you've learned and begins applying something on which to build your future reference and growth as a tec diver. Like Chapter One, it's not a short chapter either, and — bad news — sorry, it doesn't have as many pictures (though the margins are just as wide.)

In Chapter Two, you continue learning about *tec diving equipment*, especially some items you'll need for decompression or extended no stop dives. Then you'll get into *gas planning again*, and this time you're going in deep. You'll learn the basics for planning a hang (decompression) dive, and practice determining your gas supply requirements for a multiple depth dive. After that you get a math-break and head into philosophy, with some more on *thinking like a technical diver*. Then *team diving* part two goes way into gas handling and dive planning, so you get to learn two new acronyms that guide you through the tec planning process.

Building upon that comes more on *techniques and procedures*, this time getting you going on deco/stage cylinder handling. In these procedures, you get to learn . . . yes, a third acronym (Three in one chapter? Sorry, can't be helped.) That leads into some more emergency procedures, among which, you'll be glad to learn, there are no more new acronyms. The chapter finishes up with an overview of Practical Application Two and Training Dives Two and Three.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What's the difference between a stage bottle (cylinder) and decompression bottle (cylinder)?
2. How do you set up a stage bottle (cylinder) or decompression bottle (cylinder)?
3. What is the advantage of a stage or decompression bottle (cylinder) clip connection that you can cut?
4. Why might you need a lift bag and reel on a technical deep dive?
5. What are suitable lift bags and reels for technical deep diving, and where do you secure them on your rig?
6. What makes a suitable spare mask for technical deep diving, and where do you carry it on your rig?
7. What are the guidelines regarding material and equipment compatibility using enriched air and oxygen?

Equipment II

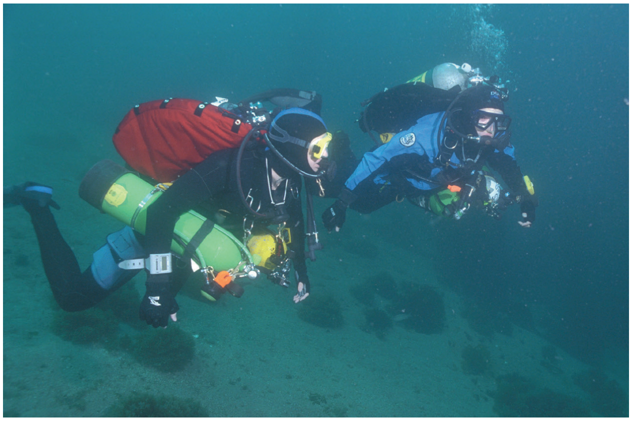
Stage and Decompression Bottles (Cylinders)

Tank, bottle, cylinder. They're all names divers have stuck on scuba cylinders and they all basically mean the same thing so we use them interchangeably. The most "technically correct" term is "cylinder." But you'll hear people call your tanks "bottles" instead of "cylinders" all the time.

Similarly, you'll hear "stage bottle" and "decompression bottle" used interchangeably, although there is a difference: stage bottles extend the working part of your dive, whereas deco bottles are cylinders with enriched air or oxygen for decompression. Both are worn on the side under the arm, clipped at the waist and on the chest, so you can remove and replace them as necessary. Since they're rigged the same and carried the same way, they're often lumped together — in fact, throughout the *Tec Deep Diver Manual* you see references to "stage/deco cylinders" when discussing handling issues that are the same, and it doesn't matter whether you're using the tanks to extend your range or for decompression. You'll learn about using both during the course.

Now to make terminology really interesting, to "stage" something is to leave it for later retrieval and use, usually a cylinder. Thus, you can stage stage cylinders, but you can also stage deco cylinders. In fact, you're more likely to stage a deco cylinder than to stage a stage cylinder.

Stage/Deco Cylinder Configuration. The typical stage/deco cylinder has a nylon rope or strap approximately 46 cm/18 in (more or less to individual needs) running from under the valve open-



You'll hear "stage bottle" and "decompression bottle" used interchangeably, although there is a difference: stage bottles extend the working part of your dive, whereas deco bottles are cylinders with enriched air or oxygen for decompression.

ing from the neck down to a band around cylinder, with a clip at each end. The rope/strap serves as handling strap underwater, and the clips secure the cylinder at the hip and chest D-rings. You may adjust these somewhat — some divers prefer the bottom clip under the valve knob instead of under the valve face.

The regulator has a second stage and SPG only, with the hoses tucked under inner tubing, bungee or surgical tubing stretched around the cylinder. You tuck the hoses so the second stage deploys with a single pull. The second stage also has a breakaway mount clip so you can secure it and avoid pulling it out unintentionally. The short hose SPG, bent up and pull-tied to the first stage is popular with many tec divers because it effectively leaves only the second stage hose to deal with. Deco cylinder regulators may have mouth blocks or mouth guards — you'll learn more about these in a bit. Fully set up and ready to go, a stage/deco cylinder should be a compact "package" that you can handle easily without anything dangling or dragging.

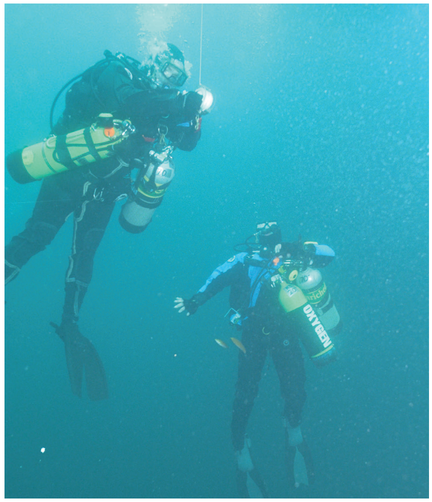
Suitable cylinders for stage/deco cylinders are those that are nearly neutral for easy handling. Avoid those that are substantially negative because they're awkward to handle. An exception is a cylinder used for oxygen that you'll stage and retrieve for decompression at 6 metres/20 feet. In this case, some divers like the added weight to help restore the weight they've lost through gas consumption during the dive.

Stage/deco bottle clips attach to the cylinder via a rope or nylon strap so that you can cut the tank away if you need to in an emergency, or in case the clip jams (it happens) and there's no other way to get out of it. This is particularly popular for wreck or cave diving because you can't cut your way out of all metal connections. A few tec divers use double-ended clips with all metal connections because it's highly unlikely that both ends would jam at the same time.

Oxygen cylinder set up as a decompression bottle package. Note the double ended clip used to secure the cylinder at the hip.

Many tec divers prefer a strap on their stage/deco bottles, which makes handling easier and makes it possible to cut away the cylinder if necessary.

You wear single stage/deco cylinders on the left. You may wear multiple cylinders on both sides, or all on the left (balance isn't an issue if you're using near-neutral cylinders). If you wear a cylinder on the right, be sure it doesn't trap your long hose — the hose must be below the hip D-ring and clip. A common configuration for wearing deco cylinders on both sides is to always wear your oxygen cylinder on the right (left-lean, right-rich).



You may wear multiple cylinders on both sides, or all on the left.

When scootering (which you won't get into during this course), you usually wear all cylinders on your left so the prop wash can aim under your right arm. Many divers prefer to wear all stage/deco cylinders on the left, scootering or not, to keep habits the same and to avoid long hose issues.

During a decompression/safety stop, you can also clip cylinders you're done using to your hip by the upper clip. Although this looks awkward, it gets them out of the way and they trail easily behind you when you swim.

During a decompression/safety stop, you can also clip cylinders you're done using to your hip by the upper clip. Although this looks awkward, it gets them out of the way and they trail easily behind you when you swim.

Lift Bag and Reel

When making a deep dive in open water, it's possible to find yourself away from the anchor line or your planned ascent line area. Sometimes it's not feasible to return to a particular point to begin your ascent. In either case, you deploy a lift bag on your emergency reel.

The lift bag and line provide reference to ascend along, making it easier to maintain your decompression or safety stops. It also marks your location for the boat and support team so they know where you are.

A suitable lift bag is brightly colored, with 45 kg/100 lbs or more lift preferred.

A suitable lift bag is brightly colored, with 45 kg/100 lbs or more lift preferred. Write your name in large letters on the bag so surface support can identify you. You can also get bright colored, elongated bags that jut well above the surface and double as inflatable signal tubes. Different areas like to use different colors, but experience shows that the best color is marine yellow. It stands out better than white (especially when the wind kicks up white caps) and it's more visible in dimmer light than is red.

Lift bag options and protocols vary depending on the local conditions and requirements. Sometimes tec divers carry two bags — one of a different color that signals for assistance from the support crew topside. Different teams may have different colors for easy identification. In some environments, such as deep sink holes, you might not need a lift bag at all (you'll practice using one as part of this course regardless of the environment you train in).

An appropriate reel is compact with ample nylon line to reach the surface. Once inflated, your bag screams upward, so your reel needs to be able to spin smoothly and rapidly, yet allow you to put a bit of drag and control on it.

An appropriate reel is compact with ample nylon line to reach the surface. Once inflated, your bag screams upward, so your reel needs to be able to spin smoothly and rapidly, yet allow you to put a bit of drag and control on it. The most common lift bag reels are those used for wreck and cave penetration. Some divers carry two reels in tandem, in case one jams.

You carry the lift bag rolled up and slung from your harness in the small of your back, held by two pieces of bungee or surgical tubing. This keeps it secure, but completely out of the way and easy to deploy when you need it.

You carry the lift bag rolled up and slung from your harness in the small of your back, held by two pieces of bungee or surgical tubing. This keeps it secure, but completely out of the way and easy to deploy when you need it.

Your reel clips to your right hip D-ring, as you already learned. Putting it there keeps it accessible and out of the way, while helping keep your long hose in place without trapping it.

When worn on the hip, your reel holds the long hose in place.

Spare Mask

It's rare to get your mask knocked off, and even then it's usually your own fault for following too close to your team mate's fin tips. It's rarer still to lose your mask and not be able to relocate it. But were it to happen on a tec dive with a deco obligation, you'd have to rely on a team mate to take you through your decompression because you wouldn't be able to read your tables and gauges. And if you'd somehow separated from the team then, well, big problems — though a computer that provides an audio cue if you ascend above your stop depth can make it feasible to "listen" your way through your decompression.

A suitable spare mask is as small and compact as possible. The usual carrying place is in a compact harness pocket on the waist band all the way back, behind the waist D-rings.

With this in mind many tec divers carry a spare mask. The spare mask isn't considered mandatory, but it doesn't take up much space, and it's an especially good idea for dives with a higher than usual potential for team separation. A suitable spare mask is as small and compact as possible. The usual carrying place is in a compact harness pocket on the waist band all the way back, behind the waist D-rings. Some divers carry a back up mask in a suit thigh pocket.

Oxygen Compatibility Review

The PADI Enriched Air Diver course taught you the basics about considerations for gas blends with more than 21 percent oxygen. As you recall, you need to follow protocols regarding materials, cleaning and handling to avoid fire and/or explosion hazard. Fire requires fuel, heat and oxygen — remove one of these and you won't have fire or explosion. Since oxygen's a given, the following oxygen compatibility issues exist to eliminate fuel and heat from the equation:

1. The standard for the dive community is that any equipment (regulator, valve, cylinder) that will be exposed to more than 40 percent oxygen at any time (including during blending) must be rated for *oxygen service*. Oxygen service means that it is oxygen clean — free of contaminants, and that it is oxygen compatible — made from materials that don't combust easily in oxygen. Some dive community members, and some areas by law, require oxygen service rating for any contact with more than about 22 percent oxygen.

2. Follow manufacturer recommendations regarding the use of their equipment with air, enriched air or oxygen. Some manufacturers require oxygen service for any enriched air application, whereas others limit the maximum oxygen percent you may use their gear with. This may create some challenges and you may have to make some choices — see the sidebar "Manufacturer Warranties and Hyperoxic Gases."

3. If you expose oxygen service equipment to gases that are not oxygen clean, or that have other contaminants, the equipment is no longer oxygen clean and loses its oxygen service rating until recleaned. An example of this is using an oxygen clean/service regulator on a standard air cylinder. Normal Grade E breathing air is **not** considered oxygen compatible, and the regulator would be considered contaminated and must be recleaned to again meet oxygen service standards. Similarly, if you fill an oxygen service rated cylinder from a standard air source, the cylinder loses its oxygen service rating. (To maintain the oxygen service standard, you need to fill the cylinder with oxygen compatible air, such as in the US, Grade E Modified, or Grade J).

4. Leave enriched air cylinder content decals and tags in place for the blender to remove. This allows the blender to confirm that the cylinder was not refilled from a non oxygen clean source. If there's any question about this, the blender will require cylinder and valve recleaning before filling.

5. To minimize heat of compression (which can be high enough to start a fire), open cylinder valves *slowly* and allow equipment to pressurize *slowly* when using enriched air and oxygen.

6. Protect oxygen service equipment from contamination. Leave it bagged or otherwise sealed against the environment until it's needed. Rinse and stow it as soon as possible when you're done with it,

and at all times, keep it away from areas or exhaust that might have contaminants. If in doubt about possible contamination, assume contamination and have the item recleaned by your PADI Dive Center or Resort.

7. The general guideline is to have oxygen service equipment recleaned annually. That works out because that's the same interval for most regulator overhauls and tank/valve visual inspections.

8. Violating guidelines regarding oxygen service and oxygen compatibility carries a severe risk of injury and/or property damage from fire and/or explosion. Follow the guidelines, and you're unlikely to ever have an incident related to oxygen compatibility.

Tec Exercise – 2.1

1. A stage bottle is used _______________ and a decompression bottle is used __________.
   - ☐ a. for decompression, for decompression
   - ☐ b. to extend the bottom time, for decompression
   - ☐ c. to extend decompression or to extend bottom time, to extend decompression or to extend bottom time
   - ☐ d. None of the above.

2. A stage or decompression cylinder is set up with a regulator that has a primary and alternate second stage.
   ☐ True ☐ False

3. The advantage of a stage/deco cylinder clip connection that you can cut is (check all that apply):
   - ☐ a. that's the usual method for removing the cylinder.
   - ☐ b. it's the fastest way to add a new clip.
   - ☐ c. it permits your buddy to remove the cylinder if you're unconscious.
   - ☐ d. None of the above.

4. You carry a lift bag and reel to provide a ___________ to ascend along and to _________ __________ ________ for the boat and support team.

5. A suitable lift bag is _____________ colored, with _________ lift preferred. You carry it in the _________ ___ _________ __________ held by two pieces of bungee or surgical tubing.

6. A suitable spare mask (check all that apply):
   - ☐ a. is small and compact.
   - ☐ b. rides in a small pocket behind the hip D-ring.
   - ☐ c. is recommended, but not considered mandatory.
   - ☐ d. must be bright orange for safety.

7. Violating oxygen service and compatibility guidelines risks severe __________ and/or property _________ from _________ and/or ____________.

Check it out:
1. b. 2. False. The regulator has one second stage. 3. d. Cutting allows you to remove the cylinder if the clip jams. 4. reference, mark your location. 5. brightly, 45 kg/100 lbs, small of your back 6. a,b, c. 7. injury, damage, fire, explosion.

Manufacturer Warranties and Hyperoxic Gases

As you realize by now, in the DSAT Tec Deep Diver and Apprentice Tec Diver courses, you're learning to use enriched air nitrox with more than 40 percent oxygen and/or pure oxygen to extend no stop time and benefit decompression.

Not only are these hyperoxic gases recommended, their use verges on the *essential* for decompression after long, deep dives. The use of higher oxygen goes probably lessens the risk of decompression sickness, because it is generally believed that for a given a decompression model, a schedule *requiring* shorter stops is more reliable than a schedule *requiring* longer stops. Without the high oxygen, you'd face impractically long decompression stops. Therefore, when a diver can get out of the water quicker (accelerated decompression), it reduces the exposure to others risks as diverse as marine predators, hypothermia, getting separated from the boat in strong currents, and so on.

Technical diving is undoubtedly safer with the use of high oxygen gases than it would be without them, which is why it is a standard practice in the tec diving community. Using hyperoxic gases, however, is not without some risk and controversy. Outside of issues you've learned related to central nervous system and pulmonary oxygen toxicity, the greatest hazard comes from the risk of fire. That's why, as you've learned, any high pressure device coming in contact with a gas with more than 40 percent oxygen (or less than 40 percent if specified by the manufacturer) must be cleaned and dedicated for use with pure oxygen.

That's easy to say, but not as easily done.

At this writing, virtually no equipment manufacturer in the dive industry warrants the use of their equipment with pure oxygen. Some specifically warn against using their equipment with enriched air nitrox mixtures containing greater than 40 percent oxygen. Nor should you consider the use of any specific equipment by a diver or instructor, or the appearance of such use in a published photo (including those in this manual) or video as an implied warranty of such use by the manufacturer, the diver or instructor, or the publisher. Yet, you will still learn in this course to use proper oxygen service equipment with hyperoxic gases including pure oxygen.

Basically it comes down to balancing the risks: the risk of getting seriously hurt or killed due to decompression sickness against the risk of getting seriously hurt or killed due to fire or explosion. Most tec divers believe – and accident data support – that provided you're using properly cleaned and compatible equipment, not using oxygen is a far greater risk than using it. In fact, while plenty of divers have been bent over the years, as of this writing only one has been seriously injured as a result of an oxygen fire using a hyperoxic gas in a technical scuba diving context. And that is in the context of tens of *thousands* of dives (at least) made with such mixtures over the past decade.

In the end the choice will be yours. If you decide to stick with the strict manufacturer's guidelines for your regulators, tanks, valves, and SPGs, you may have to choose decompression gases with no more than 40 percent oxygen, at least until manufacturers change their policies. But if so, you must then be willing to accept the risks attendant to the lengthier decompression times involved.

Most of the technical diving community believes that, the manufacturer's warnings notwithstanding, you are better off in technical diving to use oxygen and other hyperoxic mixes than not. The risk of fire and explosion is real and is, yet again, another risk you must personally assume before getting involved in technical diving. To manage and minimize that risk, be certain that any equipment you will use with a gas with more than 40 percent oxygen has been serviced for that use by a qualified professional.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

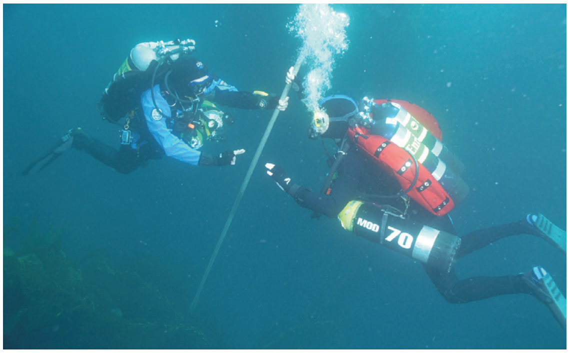
1. How do you determine required decompression stops using a single gas computer or tables?
2. How do you use switches to enriched air or oxygen to make decompression stops or safety stops more conservative when using a single gas computer or single gas tables?
3. What is accelerated decompression?
4. What is a gas-switch extended no stop dive?
5. What is your EAD when breathing pure oxygen?
6. What is an END, and what are the two different assumptions it can be based on?
7. Why do you assume your END does not change when using enriched air as compared to air?
8. How do you normally determine the "ideal" enriched air for a particular depth?
9. How do you determine your gas supply and reserve requirements for a multiple depth dive (including dives with decompression or safety stops)?
10. What is "desk top decompression software," and what are the benefits and risks of using it?

Gas Planning II

In the last chapter you learned about computing your gas volume requirements and reviewed the issues surrounding oxygen toxicity. Now you'll broaden your dive planning skills by applying these principles to tec diving no stop dive time and decompression.

Introduction to Decompression Stop and Gas Switch, Extended No Stop Diving

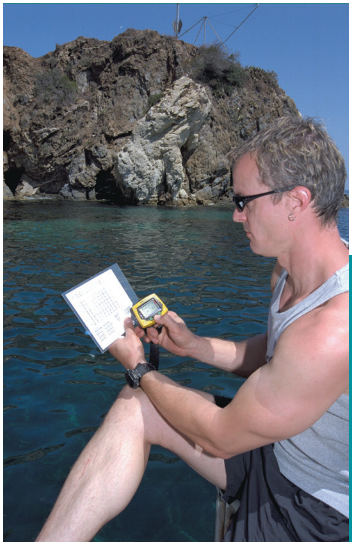
As you know already, tec diving frequently requires decompression stops due to the depth and/or duration of your dive. You make the mandatory stops in stages as you ascend so excess dissolved nitrogen diffuses out of your body tissues without substantial bubble formation and DCS. You need to be able to determine the required stops, how to maximize their effectiveness, and how (when feasible) to accomplish your dives without mandatory decompression.



Tec diving frequently requires decompression stops due to the depth and/or duration of your dive. You make the mandatory stops in stages as you ascend so excess dissolved nitrogen diffuses out of your body tissues without substantial bubble formation and DCS.

You'll learn several options for determining your decompression requirements. The first and simplest is to use a single gas dive computer (air or enriched air), or dive table. The "single gas" reference simply means that the computer or table calculates your decompression based on the idea that the diver uses the same gas while decompressing as while on the bottom.

The vast majority of currently available dive computers will calculate decompression, though they vary in the information they provide and the decompression range they cover. Check the manufacturer literature for specifics. Though you'll probably use your computer, you can also use any of several published decompression tables, such as the US Navy Standard Air Tables or Canada's DCIEM air tables. These tables specify the depths and durations for stops for given depth and time combinations. If you don't have two dive computers, you can use waterproof (laminated, for example) tables along with a timer and depth gauge for back up. You can also use the tables to help you plan your gas requirements with your computer. (Later in this course, you'll learn about using desktop decompression software to generate tables.) For maximum reliability, when planning your dives,you want to use tables and models that are within the limits of known and established test data.



If you don't have two dive computers, you can use waterproof (laminated, for example) tables along with a timer and depth gauge for back up. You can also use the tables to help you plan your gas requirements with your computer.

To determine your required decompression stops, you simply follow your computer or the table. A computer will usually tell you how long you have at each stop, and when it's okay to ascend to the next stop; some will also show your total deco time remaining. The table simply lists stops and times — you ascend to the deepest stop depth, wait the time indicated, ascend to the next and do the same, and so on.

Because your computer or tables assume you're decompressing using the same gas blend that you used on the bottom, it's easy to make your decompression more conservative. Upon ascending to a depth shallow enough to avoid oxygen toxicity, you switch to a higher oxygen EANx (or even pure oxygen in some cases) in a deco cylinder. This allows the nitrogen to dissolve from your body more rapidly than your computer or tables account for.

You complete your decompression using the higher oxygen gas, resulting in a very conservative decompression. Not only is this simple, but it's advantageous when using some tables (like the USN tables) designed for military or commercial divers that are not as inherently conservative as computers and models presently developed for sport divers. Similarly, when you make technical no stop dives, you can switch to a higher oxygen EANx, or pure oxygen, to make your safety stop extra conservative. But, remember that after switching, your computer doesn't "know" and its oxygen exposure tracking (if it does so) won't be accurate. You'll need to calculate your oxygen exposure manually (more about this later).

Because your computer or tables assume you're decompressing using the same gas blend that you used on the bottom, it's easy to make your decompression more conservative. Upon ascending to a depth shallow enough to avoid oxygen toxicity, you switch to a higher oxygen EANx in a deco cylinder.

Here's an example of how you might make such a dive: You dive to 42 metres/140 feet using EANx24 with an enriched air computer. Upon ascent, your computer or table requires you to stop at 9 metres/30 feet, 6 metres/20 feet and 3 metres/10 feet. You complete your stop at 9 metres/30 feet using EANx24 as your back gas (the gas in your doubles) and then you ascend to 6 metres/20 feet and switch to 100 percent oxygen (recall that 6 metres/20 feet is the deepest you can use pure oxygen, PO_2 1.6 ata) and finish decompression with it following your computer or table.

Accelerated Decompression and Gas-Switch, Extended No Stop Dives. Because switching to higher oxygen EANx and/or pure oxygen speeds nitrogen release, rather than "pad" your decompression to make it more conservative, you can *shorten* your required stop times by using special multiple gas computers or custom dive tables that will calculate the gas switch. This is called *accelerated decompression*, which you'll learn more about further into the course.

Similarly, you know that a multilevel profile extends your no stop dive time by giving your credit for slower nitrogen uptake as you ascend. If you ascend *and* switch to a higher oxygen blend in a stage bottle, your no stop time goes through the roof — you can make incredibly long dives without ever entering deco, and since you're using a stage bottle, you have the gas supply to make it possible. You'll learn more about planning gas-switch, extended no stop dives later; qualifying to make these dives is one of the primary benefits of the Apprentice Tec Diver certification.

Equivalent Air Depths (Continued) and Equivalent Narcotic Depths

The last chapter reviewed Equivalent Air Depths (EADs) with enriched air nitrox, so let's go one more step and figure out the EAD for 100 percent oxygen. No matter what your depth (presumably 6 metres/20 feet or shallower to prevent oxygen toxicity) the EAD always equals -10 metres/-33 feet. This is because the PN_2 (partial pressure of nitrogen) is 0, lower than air at the surface (even at altitude). The mathematical result is a constant negative depth. So, using pure oxygen underwater at any depth, nitrogen leaves your body faster than if you were at the surface breathing air.

This is not simply a mathematical curiosity, but the reason why oxygen decompression is such a big deal for tek divers. For one, it is the fastest way to get rid of excess nitrogen (or other inert gases). For another, it gives you flexibility in choosing your decompression depth. You should *never* be deeper than 6 metres/20 feet using pure oxygen, and you should never be shallower than the stop depth indicated by your table or computer. But, you can be deeper than the indicated stop depth without affecting how fast you release nitrogen, and this is *only* true when using pure oxygen. Using air or enriched air, being deeper than the indicated depth slows your nitrogen release.

For instance, suppose you've reached 6 metres/20 feet and switched to oxygen to finish your decompression. After sufficient time, your dive tables now indicate that your next stop is 3 metres/10 feet, but there's a pretty good swell at the surface. Instead of going to 3 metres/10 feet, you ascend only to 5 metres/15 feet to stay below the waves, while reducing your PO_2 somewhat. Or, suppose there's something you can hang onto at 6 metres/20 feet for a nice, restful decompression, but nothing like that any shallower. Using oxygen you can just stay put to finish your decompression. (Of course, when you're using a single gas dive computer, it will increase your decompression time since it thinks you're staying deep and using your back gas).

Equivalent Narcotic Depth (END). Equivalent Narcotic Depth calculates the expected narcosis for a gas mix with an equivalent depth as if breathing air. For instance, if a gas blend is said to have an END of 30 metres/100 feet at 60 metres/200 feet, it means that at 60 metres/200 feet breathing that blend you'd be subject to the same narcosis as if breathing air at 30 metres/100 feet.

At one time, it was common to calculate ENDs for enriched air nitrox, but today ENDs are really only relevant to gas blends with non narcotic helium (using helium blends is beyond the scope of this course). The reason is that the old assumption was that oxygen is not narcotic, and therefore EANx, with less nitrogen than air has, would be less narcotic than air.

More recently, however, it appears that oxygen is probably just as narcotic as nitrogen (or even slightly more so). Therefore, you want to assume your END does *not* change when comparing air to EANx. (Some desktop decompression software will calculate ENDs for EANx; disregard these shallower ENDs and assume that EANx is just as narcotic as air.)

Ideal Enriched Air for a Particular Depth

For most dives, the "ideal" enriched air blend for a planned particular depth is the one with the highest permissible oxygen content within oxygen limits. The highest oxygen blend gives you the most no stop time/least deco time. For the majority of dives, this is the EANx with its 1.4 maximum depth at or just deeper than the planned depth. The easiest way to find the ideal depth is to use the Maximum Depth Table in the appendix.

For example, what's the "ideal" EANx for a dive to 40 metres/130 feet? In the table's 1.4 column, find 40 (metric) or 132 (imperial) opposite 28 percent, indicating EANx28 is the "ideal" blend.

METRIC

MAXIMUM DEPTHS IN METRES OF SEAWATER

BLEND	@1.4	@1.6
21%	57	66
22%	54	63
23%	51	60
24%	48	57
25%	46	54
26%	44	52
27%	42	49
28%	40	47
29%	38	45
30%	37	43
31%	35	42
32%	34	40
33%	32	38

IMPERIAL

MAXIMUM DEPTHS IN FEET OF SEAWATER

BLEND	@1.4	@1.6
21%	187	218
22%	177	207
23%	168	197
24%	160	187
25%	152	178
26%	145	170
27%	138	163
28%	132	156
29%	126	149
30%	121	143
31%	116	137
32%	111	132
33%	107	127

Of course, the "ideal" isn't always the most practical. For instance, you may find ready access to a blend with less oxygen but not the "ideal" blend, with no meaningful difference in how it affects your no stop or decompression time. And, going with a bit less oxygen than the "ideal" blend gives you some margin for error; you can accidentally descend a bit past your planned depth without exceeding 1.4 ata. If you've made several dives, your oxygen exposure (OTUs/"CNS clock") may require a lower PO_2 than 1.4 to permit the bottom time you want.

Determining Gas Supply and Reserve Requirements for Multiple Depths and Decompression Stops

In the last chapter you learned how to estimate your gas requirements and reserve requirement for a single depth and time based on your Surface Air Consumption (SAC) rate. Now let's look at the bigger picture: your gas and reserve requirements for multiple depths, your ascent and decompression stops when using more than one gas blend. It's a bit of number crunching, but not difficult.

Conversion Factors. To simplify using your SAC rate, you can use a conversion factor for a given depth off the Conversion Factor Table in the Appendix. Your required gas estimate then becomes: SAC x minutes x conversion factor. If there's no conversion factor for the depth you need, round to the next greater depth. (For the mathematically curious, the conversion factor is simply the absolute pressure in atmospheres – Metric: (D in metres +10)/10; Imperial: (D in feet +33)/33.)

For example, if your SAC were 24 l/min, how much gas would you consume in 15 minutes at 30 metres? On the Conversion Factor Table find that the factor for 30 metres is 4.0. Then: 24 l/min x 15 min x 4.0 = 1440 litres. In the imperial system, suppose your SAC were .7 cf/min. How much gas would you consume in 15 minutes at 100 feet? On the Conversion Factor Table find the factor for 100 feet is 4.0. Then: .7 cf/min x 15 min x 4.0 = 42 cubic feet.

SAC CONVERSION FACTORS

Multiply your SAC rate by the factor to determine your gas comsumption rate at depth.

Metric

Depth (m)	Conversion Factor
3	1.3
5	1.5
6	1.6
9	1.9
12	2.2
15	2.5
18	2.8
21	3.1
24	3.4
27	3.7
30	4.0
33	4.3
36	4.6

Imperial

Depth (ft)	Conversion Factor
10	1.3
15	1.5
20	1.6
30	1.9
40	2.2
50	2.5
60	2.8
70	3.1
80	3.4
90	3.7
100	4.0
110	4.3
120	4.6

To estimate your entire dive gas supply, it's simply a matter of doing this for every depth and decompression stop, and your ascent. The TecRec Dive Planning Slate organizes your depth, conversion factor, time and blends to help you with planning. It also lets you record other planning information that you'll learn about later. In sorting out the depths and times:

- Treat the descent time as though it were spent at the first depth.
- Your ascent depth is the midpoint between the bottom and the first stop. To find this, subtract the first stop depth from the bottom depth, divide that by two and then add it to the stop depth. The ascent time is the time from the bottom depth to the first stop; divide the distance from the bottom to the first stop by the ascent rate to get the time. (You typically round the time to the closest whole minute.)

  Example: You're diving at 30 metres/100 feet and your first stop is at 12 metres/40 feet. Your ascent depth is 21 metres (30-12 = 18, 18 ÷ 2 = 9, 9 + 12 = 21) or 70 feet (100 - 40 = 60, 60 ÷ 2 = 30, 30 + 40 = 70). If your ascent rate is 10 metres/30 feet per minute, your ascent time is 2 minutes (metric: 18 ÷ 10 = 1.8 — round to 2; imperial: 60 ÷ 30 = 2).

- Ascent between stops is negligible and is handled several ways. The easiest is to add one minute to every third stop (ignore gas switches). Ascent from last stop to surface is generally disregarded.

  Example: You have three deco stops of 9 metres/30 feet for 3 minutes, 6 metres/20 feet for 5 minutes and 3 metres/10 feet for 9 minutes. You would plan your gas supply assuming 10 minutes at 3 metres/10 feet, with the extra minute accounting for ascent between stops.

- Remember that your bottom SAC rate usually differs from your decompression/safety stop SAC rate; use different rates accordingly.
- Estimate the required gas volume for *each gas blend* you'll use.
- Typically, you round to the closest litre or cubic foot. (Some divers prefer to always round up for extra conservatism, but this isn't required.)
- After you have a volume for each gas, multiply each gas volume by 1.5 to get the total volume with one-third reserve (or use the formula you learned in Chapter One for a different reserve).

Here are some examples. Try them on your TecRec Dive Planning Slate (don't worry about the columns you haven't learned to use yet.)

Metric
What is your total gas requirement, including one third reserve, if your SAC rate is 20 litres per minute and you plan a dive to 30 metres for 15 minutes followed by a 3 minute safety stop at 5 metres, using air for the entire dive? Ascent rate is 18 metres per minute.

Answer: 2103 litres

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Pla
Air	1402	2103					
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Pla
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planne

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2
30	15		20	4.0	1200	Air	
17.5 (ascent)	2		20	2.8	112	Air	
5	3		20	1.5	90	Air	

Total Air = 1200 + 112 + 90 = 1402 litres

1402 x 1.5 = 2103 litres

Here's a more detailed example involving three gas blends and decompression:

You plan to make a dive with air by following a standard air table. You plan to make the decompression more conservative by using EANx50 at 9 and 6 metres, and pure oxygen at 3 metres. Your planned dive is 45 metres for 40 minutes, with 5 minutes at 9 metres, 19 at 6 metres and 33 at 3 metres. Your SAC rate is 24 litres per minute during the working part of the dive, and 18 litres per minute when decompressing. Your ascent rate is 10 metres per minute. What are your total gas requirements for each gas, including a one-third reserve?

Answer: Air = 8452 l, EAN x 50 = 1077 l, Oxygen = 1194 l

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vo
Air	5635	8452					
EANx50	718	1077					
O_2	796	1194					

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2
45	40		24	5.5	5280	Air	
27 (ascent)	4		24	3.7	355	Air	
9	5		18	1.9	171	EANx50	
6	19		18	1.6	547	EANx50	
3	34 (33+1)		18	1.3	796	Oxygen	

Air = 5280 + 355 = 5635; 5635 x 1.5 = 8452 litres

EANx50 = 171 + 547 = 718; 718 x 1.5 = 1077 litres

Oxygen = 796 x 1.5 = 1194 litres

Imperial

What is your total gas requirement, including one third reserve, if your SAC rate is .75 cubic feet per minute and you plan a dive to 100 feet for 15 minutes followed by a 3 minute safety stop at 15 feet, using air for the entire dive? Ascent rate is 60 feet per minute.

Answer: 78 cubic feet

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Pla
Air	52	78					

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2
100	15		.75	4.0	45	Air	
57.5 (ascent)	2		.75	2.8	4	Air	
15	3		.75	1.5	3	Air	

Total Air = 45 + 4 + 3 = 52 cubic feet

52 x 1.5 = 78 cubic feet

Here's a more detailed example involving three gas blends and decompression:

You plan to make a dive with air by following a standard air table. You plan to make the decompression more conservative by using EANx50 at 30 and 20 feet, and pure oxygen at 10 feet. Your planned dive is 150 feet for 40 minutes, with 5 minutes at 30 feet, 19 at 20 feet and 33 at 10 feet. Your SAC rate is .8 cubic feet per minute during the working part of the dive, and .65 cubic feet per minute when decompressing. Your ascent rate is 30 feet per minute. What are your total gas requirements for each gas, including a one-third reserve?

Answer: Air = 282 cf, EANx50 = 39 cf, Oxygen = 44 cf

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vo
Air	188	282					
Gas	**Planned Vol**	**w/Reserve(x1.5)**	**Gas**	**Planned Vol**	**w/Reserve(x1.5)**	**Gas**	**Planned V**
EANx50	26	39					
Gas	**Planned Vol**	**w/Reserve(x1.5)**	**Gas**	**Planned Vol**	**w/Reserve(x1.5)**	**Gas**	**Planned Vo**
O_2	29	44					

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2
150	40		.8	5.5	176	Air	
90 (ascent)	4		.8	3.7	12	Air	
30	5		.65	1.9	6	EANx50	
20	19		.65	1.6	20	EANx50	
10	34 (33+1)		.65	1.3	29	Oxygen	

Air = 176 + 12 = 188; 188 x 1.5 = 282 cubic feet

EANx50 = 6 + 20 = 26; 26 x 1.5 = 39 cubic feet

Oxygen = 29; 29 x 1.5 = 44 cubic feet

Desk Top Decompression Software

You've read references throughout this manual to desk top deco software, and by now you've probably got a good idea of what it is: software for the personal computer that generates custom dive tables and other dive planning information. In the previous examples, you probably noticed that calculating gas requirements, while not difficult, is a pain in the tuckus with a lots of potential for error. Start figuring in your oxygen exposure and other variables and it gets even more tedious.

Desk top decompression software takes care of all that for you, greatly reducing the error potential. In tec diving, by far the trend is away from using prepublished tables and tedious hand calculations and toward using desk top decompression software, often combined with dive computers. There are even dive computers that link with desk top deco software, so you can preprogram the computer to calculate the dive with specific information within a given range.

Using desk top deco software has several distinct advantages:

- It generates dive tables (for primary use or computer back up) for your exact time/depth range and gas blends you'll be using. You'll seldom find preprinted tables that get as close.
- It calculates gas supply requirements based on your SAC rates or RMV, and adds in the reserve of your choice.
- It calculates OTU and "CNS clock" oxygen exposure.
- If you're planning a computer dive, it provides a way to estimate decompression, gas supply needs, oxygen exposure, etc., for dive planning. Since you can set variables, you can make the software calculate very similarly to your computer; preprinted tables (especially military ones) may depart significantly from what your computer would require for a dive.
- It reduces the potential for human error in several aspects of dive plan.
- Most programs allow you to alter the decompression model to be more or less conservative based on numerous factors (personal physiology, water temp, etc.)
- With a laptop computer and portable printer, you can generate tables in the field as needed.
- It saves time. Lots!
- It makes it feasible to quickly compare the variables of several possible dive profiles; by hand this takes hours.
- It can automatically generate contingency tables for deeper/longer dives than the one planned.

Of course, using any decompression software, dive computer or dive table carries risks that you must accept. Because people vary in their physiology, no software, dive computer or table can guarantee that DCS or oxygen toxicity will never occur, even within the limits they provide. Extremely long dives, dives involving gases other than oxygen and nitrogen, and dives with reverse profiles carry a risk of being somewhat experimental because they may take you outside the body of well established test data.

It's worth noting that despite the potential risk, desk top deco software has an excellent track record, and planning with it is quickly becoming a standard operating procedure for many types of tec diving. There are several types available for you to choose from, based on features, conservatism, etc. See your PADI Dive Center or Resort about the choices available.

Planning with desk top deco software is quickly becoming a standard operating procedure for many types of tec diving. There are several types available for you to choose from, based on features, conservatism, etc.

Tec Exercise – 2.2

1. Using a single gas computer or table to compute your decompression, you (check all that apply):
   - ☐ a. interpolate the depth based on the depth mid-point.
   - ☐ b. determine an average depth based on five minute interval samples.
   - ☐ c. simply follow the computer or tables.
   - ☐ d. All of the above.
2. To use switches to higher oxygen enriched air or oxygen to make your deco stops more conservative when using a single gas computer you (check all that apply):
   - ☐ a. use a blend with higher oxygen than you used on the bottom.
   - ☐ b. follow the computer or table's deco requirements as if using the same gas you used on the bottom.
   - ☐ c. do not switch until you're shallow enough to do so without unacceptable oxygen toxicity risk.
   - ☐ d. None of the above.
3. Accelerated decompression (check all that apply)
   - ☐ a. is a technique for increasing your ascent rate with your BCD.
   - ☐ b. is shortening your decompression by switching to a gas with more oxygen than you used on the bottom.
   - ☐ c. is possible using special multiple gas computers.
   - ☐ d. is possible using custom dive tables.
4. A gas-switch, extended no stop dive (check all that apply):
   - ☐ a. is a technique for getting very long no stop limits.
   - ☐ b. requires switching to a higher oxygen blend after you ascend to a shallower level.
   - ☐ c. is possible using special multiple gas computers.
   - ☐ d. is possible using custom dive tables.
5. When breathing pure oxygen, your EAD is always ______________.
6. __________ ____________ __________ calculates the expected narcosis for a gas mix with an equivalent depth if breathing _________. It can be based on the assumptions that oxygen either is or is not ______________.
7. You assume your _________ does not change when using enriched air as compared to air because it appears oxygen is just as ___________ as ___________.
8. The "ideal" enriched air for a dive to 43 metres/140 feet would be _________.
9. Your SAC conversion factor for 39 metres/130 feet is _________.
10. Advantages and risks of using desk top deco software include (check all that apply):
    - ☐ a. Calculates gas supply requirements, OTU and "CNS clock."
    - ☐ b. Allows you to estimate dive computer deco requirements.
    - ☐ c. Saves time.
    - ☐ d. May have unacceptable risk if dive is outside the body of well established test data.

Check it out:
1. c. 2. a,b,c. 3. b,c,d. 4. a,b,c,d. 5. -10 m/-33 ft. 6. Equivalent Narcotic Depth, air, narcotic. 7. END, narcotic, nitrogen. 8. EANx26. 9. 4.9. 10. a,b,c,d.

Thinking Like a Technical Diver II

In the last chapter you learned a bit about the characteristics of top tec divers and looked at how they think. By adopting their characteristics and learning to think in the same ways, you're on the road to becoming a successful tec diver yourself.

One good characteristic to develop if you want to last a long time in tec diving is a moderate dose of paranoia. Tec divers dedicate themselves to applying, following and responding to the world's most quoted aphorism, Murphy's Law:

Anything that can go wrong, will go wrong.

Tattoo that on the back of your hand if you have to. Murphy's Law serves you well as a tec diver if you assume that everything that can fail will fail. Assuming failures prompts you to plan for them. Likewise, take – about a technical dive for granted. If you didn't pack it, no one has it. If you don't plan for someone to do it, it won't happen. If you don't check that the anchor's secure, it will drag, etc.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What do you assume about every technical dive?
2. What do you take for granted about a technical dive?
3. What question do you ask yourself as you plan each step in a technical dive?
4. What is your most important resource in an emergency, and what provides this resource in an emergency?
5. What is the principle for your gas reserves and how do you apply it during an open water deep technical dive?

As you plan each step in a dive, simply ask yourself, "What aspect of this can fail and hurt or kill me?" For every reasonably possible failure or problem you can imagine, have a workable solution before beginning the dive. Within reason, make contingency plans that do not require your teammate's assistance as your first option. Remember that it's impossible to anticipate all problems — but you can anticipate the most common and likely.

Reserve Gas

Imagine you're at 50 metres/165 feet, right at the end of your planned bottom time, and you get entangled enough that it's going to delay your ascent three or four minutes. Suppose you've got only about 25 bar/350 psi left in your cylinders and that the three or four minutes will put you over your planned decompression, for which you have only the exact amount of gas you need. Serious trouble — you're faced with running out of gas before you get untangled, and if you do get undone before running out, you're going to run out of gas before completing your hang. If you don't drown, you get bent — not much of a choice. Now suppose the same situation, but you've got lots of gas left in your doubles and a healthy reserve in your decompression gas. Trouble? No, an irritation. You have to deco longer than you wanted, but you've got it covered.

Clearly, in an emergency or faced with a problem, your most important resource is *time*. Time gives you the opportunity to correct, abort or otherwise handle problems. Underwater, your gas supply provides time, so it's your reserve that provides the time you need to deal with an emergency. It is especially important when faced with an unusual emergency for which you don't have an immediate planned response. Treat your reserve as sacred — it has no other purpose but for emergencies, ever. Another five minutes on a really cool wreck is not an emergency.

The principle for your gas reserves is simple: at the end of the dive, if you had no emergency, you should still have all your reserve. Supposing you're using the rule of thirds. For your bottom gas, use no more than two thirds of supply on the bottom and during all deco stops that you make with it — determining the pressure at which you need to start your ascent should be part of your gas planning (you'll learn to do this a bit later). For decompression gas, use no more than two thirds for all stops with each gas.

If you have no emergency and make the dive as planned, but you finish with less than or substantially more than your planned reserve, recheck your calculations and/or redetermine your SAC rate. Figure out where the difference came from and account for it in future dives.

The rule of thirds provides a margin for error in case you consume gas more quickly than expected, to cover a regulator free flow prior to shutting it down, and to assist a team mate with a gas supply problem. But under some circumstances, you may want to increase your reserve beyond a third. You might do this, for example, if conditions are highly likely to increase your SAC rate due to exertion or cold (especially your deco SAC rate), or there's a higher than normal possibility that you might slightly exceed your planned depth or time. An extra reserve's a good idea if the dive appears reasonable to make, but your team has some unanswered questions about particular variables. When in doubt, up the reserve.

Assume that anything that can go wrong will, take nothing for granted and you have the basis for planning tec dives.

Tec Exercise – 2.3

1. Assume about every tec dive that anything that can go ____________ will go ______________.
2. The only thing you should take for granted about a technical dive is ___________.
3. As you plan a tec dive, you should ask yourself, "What aspect of this can ________ ____ ____ _______ ___ _______ _____?"
4. In emergency, your most important resource is ____________. You get this resource from your ____________.
5. At the end of a dive that goes as planned, you should have ___________ of your reserve left.
   - ☐ a. most
   - ☐ b. half
   - ☐ c. a third
   - ☐ d. all

Check it out.

1. wrong, wrong. 2. nothing. 3. fail and hurt or kill me. 4. time, reserve. 5. d.

Team Diving II

In Chapter One, you learned that tec diving requires team diving, which is in many respects a step up from the buddy system. You learned that you've several responsibilities to your team, but that you're also responsible for being self sufficient, with your team mates primarily your second option in an emergency.

Team diving means that you plan your dives as a team, and that you dive in a compatible manner. In this chapter, you'll begin developing your skill in team planning, which includes several checks and steps that you perform together as a team. It also includes learning hand signals unique to tec diving.

A Good Diver's Main Objective Is To Live – Team Dive Planning

One characteristic of a tec dive is that planning and prepping for it often takes longer than the dive itself. With what you've learned already, this should come as no surprise — there's a lot to consider and plan for.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the seven primary segments to planning a deep technical dive ?
2. What recall phrase can you use to recall the seven segments for planning?
3. What are the substeps for each of the seven segments?
4. Why do all team members on a technical dive usually use the same gases?
5. What four markings should be on every cylinder used in a technical dive?
6. What cylinder markings should be easily read by your team mates while wearing the cylinder?
7. Why must the cylinders be marked as described?
8. Who must check the pressure and oxygen analysis of every cylinder used in a technical dive?
9. What is the predive check recall phrase for technical diving?
10. What steps do you include in a technical dive predive check?
11. How, in the field, do you determine the one-third pressure for cylinders?
12. How do you perform a bubble check?
13. How do you perform a descent check?
14. How do you use one hand to signal numbers to a team mate?
15. What do the thumbs-up, fist and "okay" hand signals mean during a tec dive?

An important issue is that you don't forget anything crucial in your dive plan. It's easier to keep your plan complete if you think in terms of seven primary segments that comprise each tec dive: Gas supply, Decompression, Mission objective, Oxygen, Inert gas narcosis, Thermal, and Logistics. If you think about it, everything you've learned so far fits into one of these categories.

To help you recall these, remember "A **G**ood **D**iver's **M**ain **O**bjective **I**s **T**o Live." Any variation that you remember better is fine, as long as it hits all the points. This acronym (okay, not really an acronym, but close enough) stands for:

Good – **G** – **G**as management
Diver's – **D** – **D**ecompression
Main – **M** – **M**ission
Objective – **O** – **O**xygen
Is – **I** – **I**nert gas narcosis
To – **T** – **T**hermal exposure
Live – **L** – **L**ogistics

Within each of these segments, you have substeps and considerations that you need to plan for and check before each dive. The Cambrian Foundation, well known for leading edge tec diving for science and exploration, developed using these elements as the core for the dive planning process. Hundreds of Foundation dives show that this process works. You will usually begin this process well before the dive, analyzing the variables that apply as you determine the optimimum gases, decompression schedule, and so on. You'll review the initial plans and confirm that it's still appropriate (due to conditions, etc.) just prior to your dive.

What you've already learned and practiced covers much of what A Good Diver's Main Objective Is To Live prompts you to remember. Here are some points you and your team need to be sure of for each segment to assure you're covering the substeps; you'll be learning more about these as you progress through the course and as you grow as a tec diver.

A **G**ood – **G**as management

1. Plan sufficient gas for the dive, plus the reserve, for each diver. Determine gas actually available and compare to gas requirements.
2. All divers *personally* analyzed their gas immediately before the dive.
3. Mark all cylinders appropriately.
4. All cylinders have a second stage at all times (except argon).
5. Test all valves and regulators.
6. Plan for gas termination, malfunction, or high gas consumption.
7. Determine turn pressure for bottom gases.
8. Confirm that team mates have compatible (ideally the same) gases.

Diver's – **D**ecompression

1. Calculate the decompression and compare it to the gas supply planned.
2. Calculate back up decompression schedules and contingency tables, or have a back up computer — all divers have entirely independent methods for determining their deco.

Main – **M**ission

1. The entire team understands and agrees on the mission (objective).
2. The mission is reasonably doable within the dive plan.
3. All team members know their roles and are qualified to perform them.
4. The mission has been made as simple as possible.
5. You can abort the dive at any point, mission notwithstanding.
6. If it would help and is possible, you have practiced the mission on land or in shallow water first.
7. All team members agree that the *primary* mission is for everyone to come back unhurt.

Objective – Oxygen

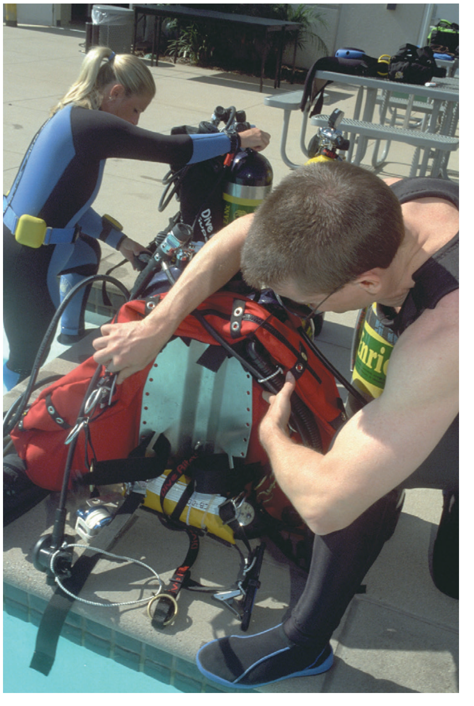
1. The PO_2 for the planned max depth and bottom gas is 1.4 ata or less.
2. On gas-switch, extended no-stop dives, the PO_2 for the second EANx blend and depth is 1.4 ata or less.
3. The PO_2 for the planned decompression stops and decompression gases is 1.6 ata or less.
4. The oxygen exposure (OTUs and "CNS clock") for the entire dive stays within accepted limits.

Is – Inert gas narcosis

1. For the planned depth and objective, narcosis will not be a significant factor.
2. The objective has been simplified as much as possible, and the dive planned as shallow as possible.
3. All divers have experience working at the planned depth and in the conditions present.

To – Thermal exposure

1. Team exposure suits are adequate for the planned duration and any reasonable contingency extended duration.
2. If using argon in a dry suit, there's adequate gas for the dive.
3. The team is prepared for the consequences of a major dry suit failure, if dry suits are used.



A Good Diver's Main Objective Is To Live — something you'll practice in repeatedly in this course.

4. As part of the predive check, all divers inspect and check dry suit valves, zippers and seals for integrity and function.
5. If using a wet suit, there's adequate buoyancy compensation and insulation to allow for suit compression at depth.

Live – Logistics

This tends to be extensive and begins well before the dive. Each of the previous segments generates logistical considerations, most involving who, how, what, where, when. Note these as you plan; examples include:

1. Establish who is responsible for providing what equipment/gas etc.
2. Establish who is qualified and will handle surface and underwater support (if necessary).
3. Establish team dive leaders and project leader.
4. Establish when and where teams will meet.
5. Determine where to find the closest emergency medical facility.
6. Assure that all project members know where to find the first aid kit and emergency oxygen, and that they know how to use it.
7. Assure that all project members know where to contact help.
8. Etceteras . . . .

Team Diving Gas Handling Considerations

As you noted in the Good step, team planning includes gas handling considerations. This includes choosing the appropriate gas blends to use, and checking and marking your cylinders so that there's no confusion about whose is whose, what's in a tank or how deep you can breathe from it safely.

Gas Selection. You and your dive team will usually plan your dive using the same gas blends throughout the dive. In some instances, though not as ideal, you may use different blends, but chosen so that they're compatible with each other's decompression requirements. You do this for several reasons.

The most important reason for matched/compatible gases is so team mates can use each other's gases in an emergency without compromising their deco schedules. Second, it reduces confusion about gas switches, and what your team mates are breathing at a given depth. Third, it allows team mates to share deco schedules in case of lost tables, computer failure, etc. Fourth, it keeps your team together because everyone will have similar limits and similar deco stop requirements.

Cylinder Markings and Labels. Besides using the same gases, it's imperative that you mark all your cylinders — doubles, stage and deco cylinders — appropriately. There are some regional variations (some of which local regulations impose), but the following four markings/labels have become generally standard among tec divers.

Color coding – Enriched air nitrox normally has a wide green band with yellow borders, and label "nitrox" or "enriched air nitrox." Oxygen is normally all white or all green with large label or sten-

Enriched air cylinders have a large green and yellow band to identify them. If used with air, as these doubles are, they're still marked and handled like any other gas blend.

Oxygen cylinders are green or white and clearly labeled "oxygen."

Argon cylinders are so small that they're not likely to be confused with other cylinders, but you should still mark them clearly with a "Do Not Breathe" warning.

ciled letters reading "oxygen." Argon is usually in a small cylinder that has a large "ARGON — DO NOT BREATHE" label.

The diver's name and the gas blend show clearly on this diver's stage/deco cylinder.

Analyzed content – This should be large enough and placed so that your team mates can read it while you're wearing the cylinders. For example, "EANx60" or "Oxygen."

You can invest in commercially made tank wraps with the maximum depths for popular blends preprinted on them.

Maximum depth – Near the analyzed content and *in large figures that your team mates can read easily*, mark the maximum depth you can breathe the gas blend. This is normally based on the 1.4 ata PO_2 for your doubles and stage cylinders, and the 1.6 ata PO_2 for deco/safety stop cylinders. This is simply the depth, such as "6 METRES" or "50 FEET." Since everyone's usually using the same measuring system, metric or imperial, it's more common just to have the number, such as "6" or "50." Characters about 5 - 8 cm/ 2 - 3 in high are typical size.

Diver's name – This avoids confusion, especially when you stage cylinders and retrieve them later.

As you learned during the PADI Enriched Air Diver course, cylinder markings are important for your safety so you don't breathe the wrong gas by accident. In technical diving, the cylinder markings have several safety benefits. For one, they identify whose cylinder is whose so you dive with the cylinders you personally checked. The markings clearly identify what is in each cylinder and the maximum depth you can breathe from it, reducing oxygen toxicity or decompression sickness risk. By marking so your team mates can read what's in your cylinders and the maximum depths, you make it possible for your team mates to easily double check what you're breathing, and vice-versa. Finally, clear, distinct and standardized markings reduce confusion, especially when you're task loaded.

Additional markings – Besides the four required markings, you may have other information on your tanks, such as the fill date and the blender's name and analysis. In locations where recreational divers might recover "lost" cylinders they find, some divers will also label or tag their cylinders with "Decompression Gas — Do Not Remove."

You can readily find commercially made labels for many of the required markings, such as the yellow and green bands for EANx cylinders. Others may be harder to come by, and in any event tec divers go through a lot of labels, so it's common to simply use gray or white duct tape and a permanent black marker.

As a reminder, just as in recreational enriched air diving, **all divers must personally check the pressure and analyze the contents of every cylinder they will use**. No exceptions. And for tec diving, you analyze the gas right before the dive as you set up, even if you've analyzed it earlier. It's your butt on the line — check it yourself.

Predive Check

In the last chapter you learned that technical diving uses a predive check like recreational diving does, only expanded to meet the demands it imposes. In fact, just as you enter the water, can use the same recall phrase (also technically not an acronym, but close enough) you learned as an Open Water Diver: **B**egin **W**ith **R**eview **A**nd **F**riend, with new and modified details for the BWRAF. The only problem with Begin With Review And Friend

TWO

is that it's not really tec-sounding, so the TecRec version is **B**eing **W**ary **R**educes **A**ll **F**ailures. (Pretty cool, huh?) This stands for:

Being **- B - B**CD: Confirm connection and proper operation of all valves for both BCDs (if using a back up) or BCD and dry suit.

Wary **- W - W**eight: Confirm that weight system is properly secured. If heavy weight diving, confirm ample buoyancy and adequate back up buoyancy.

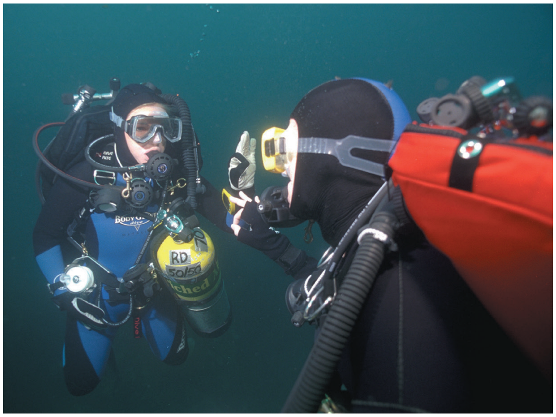
Reduces **- R - R**eleases: Confirm all releases and straps are secure and intact (including mask, fins, gauges, stage straps), that all stage/deco cylinders can be cut away, that any large equipment can be released for ditching easily.

All **- A - A**ir (gas): For yourself and team mates, confirm all manifold valves are all the way open; test breath primary and secondary, confirm that no equipment is trapping long hose; confirm that deco cylinders are pressurized but the valve is closed; determine the one-third-used pressure point for your bottom gas (this is when you usually start to head back to the ascent point; you'll also learn to determine at what pressure you need to be ascending — more about this later).

1. Divide your SPG pressure by three and subtract from total to determine when you've used the first third. E.g.. If your SPG reads 210 bar, 210 ÷ 3 = 70; 210 - 70 = 140 bar. If it reads 3000 psi, 3000/3 = 1000; 3000-1000 = 2000 psi.
2. If your pressure isn't evenly divisible by three, round *down* to the next "round" number that is, divide by three and subtract from the total pressure. E.g.: If pressure is 200 bar, round to 180 bar; 180 ÷ 3=60; 200 - 60 = 140 bar. If pressure is 2900 psi, round down to 2700. 2700 ÷ 3= 900; 2900 - 900 = 2000.

Failures **- F - F**inal Check: Check each other head to toe looking for loose or missing gear. This step finishes in the water with a bubble check and usually a *descent check*.

A *bubble check* looks for leaks in your manifold, first stages and BCD. You and your team mates enter the water and dip your manifolds below the surface so you can check each other for bubbles. You do the same on all your stage/deco bottles. The dive doesn't start until all leaks, even small ones, are handled. Sometimes you make a bubble check by descending into shallow water, checking each other, and then continuing down on the dive. When possible, also check regulators in the water just under the surface.



A descent check takes place, when feasible, just after you and your team head down at about 6 metres/20 feet or so, or at the first level you stage your deco cylinders. Your team pauses and you make a final check for loose gear, correct stage/deco cylinder placement, that everyone's breathing the correct gas, and so on.

A *descent check* takes place, when feasible (it isn't always) just after you and your team head down at about 6 metres/20 feet or so, or at the first level you stage your deco cylinders. Your team pauses and you make a final check for loose gear, correct stage/deco cylinder placement, that everyone's breathing the correct gas, and so on. You also double check for bubbles, and sometimes, such as in rough conditions, you might actually do the bubble check during the descent check instead of at the surface. Due to current or logistics, sometimes you combine the descent check with the bubble check in very shallow water (just below the surface), or you wait until you reach the bottom.

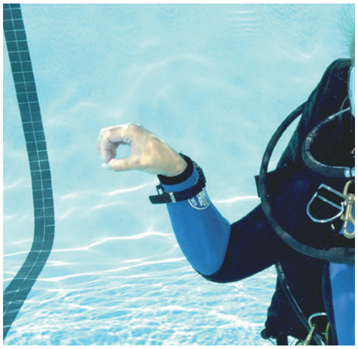
Technical Diving Hand Signals

Most hand signals you learned for recreational diving apply to tec diving, but there are some variations. Because BCD adjustments, holding a line or light, etc. may occupy one hand nearly constantly, tec hand signals usually use only one hand. This is especially true for numbers, as shown on the next page.

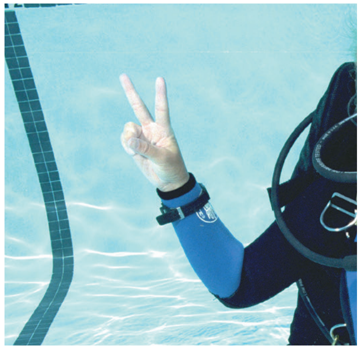
In tec diving, you generally respond to a signal with the same signal. Returning the same signal assures that you understand your team mate's signal. With a command signal, you always return the command signal to verify that you understand.

To signal a large number, show the digits rather than totals. For example, to signal "184," you signal "1," then "8" and then "4."

Another signal that differs somewhat in recreational diving is the "thumbs up" signal. In recreational diving, it means "up" or "go up" or "surface" in a rather general sense. You determine its precise meaning through context. In tec diving, the signal is a *command signal* meaning "**end the dive now**." When a team mate gives thumbs up, you go — you don't dispute or question it; the dive's over. To signal something like "let's go up there,"


Zero

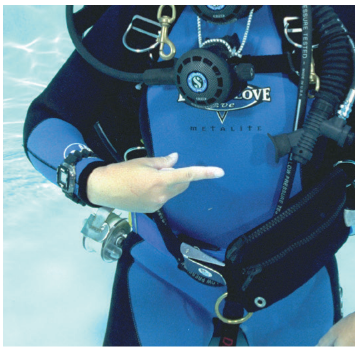

One


Two

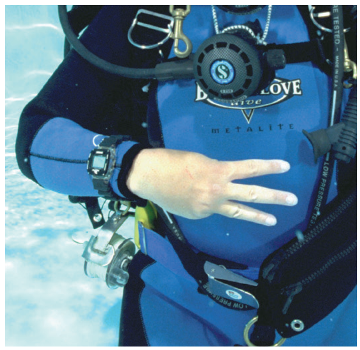

Three


Four


Five


Six


Seven


Eight


Nine

To signal 184, signal one, eight and four.

End the dive.

Hold

Okay

you point where you want to go with your index finger.

The second command signal is *hold*. (To signal, make a fist.) This means stop everything while sorting through a problem or situation.

The third command signal is okay. (Same signal as in recreational diving.) This means that you need to confirm that you are okay because your team mate has concerns about your well being.

A final difference between signalling in recreational diving and tec diving is that in tec diving, you generally respond to a signal with the same signal. If your team mate signals "thumbs up," you reply "thumbs up, " rather than "okay" to mean "I understand." Returning the same signal assures that you understand your team mate's signal. With a command signal, you always return the command signal to verify that you understand.

Tec Exercise – 2.4

1. The seven primary segments to planning a deep technical dive are ___________, ____________, ______ ______ _______, ________ _______, _______ ________, ____________ and ___________.

2. You can remember the seven primary planning segments by remembering A _________ ___________ _________ ________ _____ _____ __________.

3. Substeps to each of the seven segments include (check all that apply):
   - ☐ a. maximum depth for gases.
   - ☐ b. determining contingency deco schedules.
   - ☐ c. considering gas supply, analysis and markings.
   - ☐ d. where to find the closest emergency medical facility.

4. Team members on a technical dive usually use the same gases because (check all that apply):
   - ☐ a. it allows team mates to share gas in an emergency.
   - ☐ b. it allows team mates to share back up decompression data in case of table loss or computer failure.
   - ☐ c. it reduces confusion about gas switches.
   - ☐ d. you generally get a better price buying large volumes of the same gases.

5. Markings that should be on every cylinder used in a technical dive include (check all that apply):
   - ☐ a. color coding.
   - ☐ c. total volume.
   - ☐ b. analyzed content.
   - ☐ d. maximum depth.

6. The cylinder markings that your team mates should be able to read easily while you're wearing the cylinder are the ____________ ____________ and the _________ _________ for the gas blend.

7. Cylinders must have the standardized markings described in this chapter (check all that apply):
   - ☐ a. to reduce oxygen toxicity or decompression sickness risk.
   - ☐ b. so team mates can check each other's breathing gases.
   - ☐ c. to reduce confusion when task loaded.
   - ☐ d. to make sure that the cylinders you use are the cylinders you analyzed.

8. Divers must personally check the pressure and oxygen analysis of every cylinder they will use.
   ☐ True ☐ False

9. The predive check recall phrase for tec diving is __________ _________ _________ ___________ _________.

10. Steps in the predive check for a tec dive include (check all that apply):
    - ☐ a. checking your and your team mates BCDs and back up BCDs (or dry suits) connection and operation.
    - ☐ b. confirming that all releases are secure.
    - ☐ c. making sure nothing traps the long hose.
    - ☐ d. a bubble check and a descent check.

11. If you have 230 bar/3400 psi, what is your one-third turn pressure? Answer __________.

12. When performing a bubble check (check all that apply):
    - ☐ a. wait until you reach the maximum depth to perform the check.
    - ☐ b. you do not dive if there are major leaks (minor leaks are okay).
    - ☐ c. it's acceptable to make the check out of the water if advantageous.
    - ☐ d. None of the above.

13. When making a descent check (check all that apply):
    - ☐ a. you usually (not always) pause at about 6 metres/20 feet.
    - ☐ b. confirm gear placement and double check for bubbles.
    - ☐ c. sometimes you wait until you reach the bottom.
    - ☐ d. None of the above.

14. To signal the number 27 to your team mate, you would simply signal "9" three times, or any other combination that totals 27. ☐ True ☐ False

15. In tec diving, the thumbs up signal means
    - ☐ a. this is a way cool dive.
    - ☐ b. let's go up a bit.
    - ☐ c. end the dive now.
    - ☐ d. Any of the above may be correct, depending on the context.

Check it out:
1. oxygen, decompression, inert gas narcosis, gas management, thermal considerations, mission, logistics. 2. Good Diver's Main Objective Is To Live. 3. a,b,c,d. 4. a,b,c. d. may be true at times, but it's not a real consideration. 5. a,b,d. 6. analyzed content, maximum depth. 7. a,b,c,d. 8. True. 9. Being Wary Reduces All Failures (or Begin With Review And Friend). 10. a,b,c,d. 11. 160 bar/2300 psi. 12. d. 13. a,b,c. 14. False. You would give the signal for "2" and then the signal for "7." 15. c.

Techniques and Procedures II – Decompression and Stage Cylinder Handling

In the last section, you learned that you can spend more time planning a technical dive than the dive itself takes. That's the nature of the beast. Similarly, when you make a deep dive that requires decompression, you usually spend more time ascending and decompressing than you do on the bottom. This is why so many of the skills you develop and practice in the Tec Deep Diver course focus on the decompression aspects of the dive — it's actually the majority of the dive. If you're completing the Apprentice Tec Diver course, you won't be certified for decompression diving, but you'll practice and apply some of the basics during simulated decompression dives. This provides the basis for continuing later through the rest of the Tec Deep Diver course.

In Chapters Three and Four, you'll learn about determining schedules for gas-switch, extended no stop dives and for decompression dives. For now, let's look at the water skills and procedures you'll need to apply those schedules; you'll be practicing these skills beginning in Training Dive Two.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is the most important skill you need for decompressing, and why?
2. When decompressing, what is the ideal body position and where should you put your stop depth in relation to your body?
3. What is the proper ascent rate on a decompression dive?
4. What is the procedure for putting on a stage/deco cylinder?
5. In what order should you stack stage/deco cylinders?
6. What is the procedure for removing and leaving a stage/deco cylinder?
7. What is one of the most common preventable causes of death in technical diving?
8. What are five guidelines that reduce the chance of accidentally switching to an unsafe gas blend at depth?
9. What is the procedure for switching gases while underwater?
10. What is the recall acronym for gas switches, and what does it stand for?

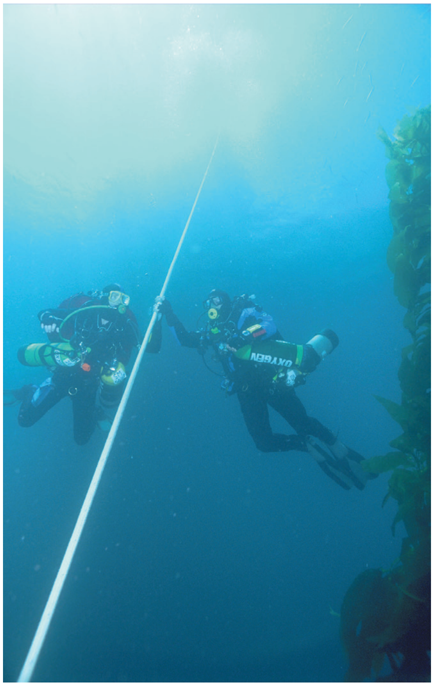
TWO

Making a Decompression Stop

In the PADI Advanced Open Water Diver course, Deep Diver course and in other courses, you've practiced making safety stops; they're probably routine for you. Compared to a safety stop, however, a decompression stop demands more from you. With a safety stop, close counts — the norm is 5 metres/15 feet, but it really doesn't matter much if you fluctuate between 6 metres/20 feet and 3 metres/10 feet. With a decompression stop, it's important to hold the required depth and not vary too much from it — especially upward.

For this reason, the most important skill when it comes to making decompression stops is *precise buoyancy control and the ability to maintain depth for extended periods.*

Significant variation from your required stop depth can affect the quality of your decompression, increasing your DCS risk. When decompressing with high oxygen gases or 100 percent oxygen, descending by accident can raise your PO_2 above 1.6 ata, making your oxygen toxicity risk — which can lead to drowning — unacceptably high.



When decompressing,you want to keep the stop depth at about mid chest level, and the ideal position is horizontal.

Much of the time, you can decompress on a weighted line suspended from a boat, along a steep-sloping bottom, on the anchor line, or with some other fixed reference that allows you to steady yourself at the stop depth. That's pretty easy. But, it doesn't always work out that way, and you may find yourself having to hover neutrally buoyant in midwater for your entire decompression. It's more tedious, but doable, and you'll practice doing so as part of this course.

With safety stops, it really doesn't matter whether you hang horizontal, vertical, upside down or what, and it really doesn't matter whether you hold the stop depth at your ankles, waist, chest or eye level. (With a safety stop what really matters is that you make one.) When decompressing, it's more critical. You want to keep the stop depth at about mid chest level, and the ideal position is horizontal. Horizontal isn't always possible, but the closer you can get, in theory the better because that's the position that maximizes the lung surface area available for gas exchange when submerged.

Ascent Rate

There's been much ado in the dive press about ascent rates, but here's the bottom line when it comes to decompression diving: you ascend at the rate your dive computer or table dictates. If you ascend too slowly or too quickly with a table, you're deviating from the required decompression and increasing your DCS risk; there's some tolerance for error, but you should try to be pretty close. If you're diving with a computer, ascending too slowly's not a huge issue because your computer will simply increase your decompression requirements as needed. However, it can't correct much for ascending too fast, though it will usually bleep, blink and otherwise alert you until you slow down.

You'll probably find that typical ascent for deco diving is 10 metres/30 feet per minute. Some desk top deco software and some dive computers have variable ascent rates, with as fast as 18 metres/60 feet per minute during the deeper part of the dive, then slowing to 10 metres/30 feet per minute, and sometimes slowing even more near the surface. Whatever the prescribed ascent rate, that's the rate you should follow.

Stage/Deco Cylinder Procedures

If you're making a decompression dive, the vast majority of the time you'll have one or more decompression cylinders, so let's look at the procedures for donning, removing and staging decompression cylinders.

Donning Stage/Deco Cylinders. A full tec rig plus a couple of stage/deco cylinders gets pretty heavy, so normally you kit into your doubles and other gear, get into the water and then put on your stage/deco cylinders (but not always — in some places with current, divers put on stage/deco cylinders before entering the water). Often you'll remove your stage/deco cylinders underwater to lighten and streamline yourself, then retrieve them to use later. In both cases, you need to know how to don stage/deco bottles in the water.

To don a stage bottle, first hold it by the lower clip and secure it to your waist D-ring. Then connect the top clip to a shoulder D-ring.

Start by making sure that all the hoses are securely tucked under the inner tube/bungee bands so they don't drag or entangle you. Next, hold the entire rig by the bottom clip in your left hand (should be no problem with a near-neutral cylinder) and clip it to your left hip D-ring. Then, swing the top up and secure the upper clip to a left side chest D-ring. Check that the cylinder's not trapping anything you need to access, and that the valve is closed (in case you didn't close it before donning it), though you may leave the regulator pressurized.

If you're wearing two or more cylinders, you can wear cylinders on the right and left, or all on the left. If you're wearing a cylinder on the right, the most common configuration is to put the higher oxygen gas on the right — remember Right-Rich, Left-Lean. When clipping on to the

When clipping on to the right hip D-ring, be cautious not to trap your long hose under the cylinder; the hose needs to be below the clip on the D-ring.

right hip D-ring, be cautious not to trap your long hose under the cylinder; the hose needs to be below the clip on the D-ring.

Wearing stacked cylinders on the left is an option often used by scootering divers because it allows them to direct the prop wash into unobstructed water under the right arm. Some divers prefer wearing all cylinders on the left, scootering or not, to avoid having to deal with keeping the long hose free, and to keep their handling procedures uniform. With near-neutral cylinders, left side stacking doesn't cause much of a balance problem.

If wearing multiple cylinders on one side, a cylinder that you'll stage (leave at some point) first goes on top. Likewise, the cylinder that you're breathing from goes on top; when you switch from one gas blend to another, you remove the top cylinder and either put it underneath, or hang it from your hip D-ring by the top clip.

When wearing multiple cylinders on one side, the cylinder that you're breathing from goes on top.

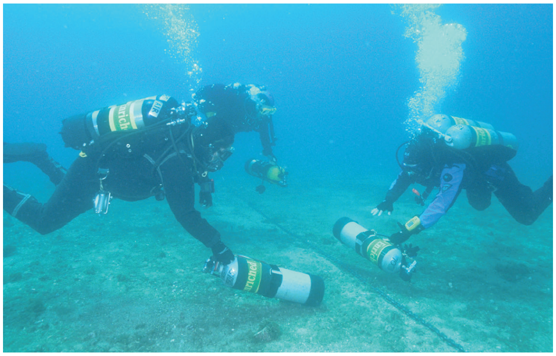
Removing Stage/Deco Cylinders. Before exiting the water, and to stage a cylinder, you'll need to remove your stage/deco cylinder(s). The process is essentially donning it in reverse. First, confirm that the valve is closed and that you've tucked all the hoses to avoid them tangling and snagging. Second, unclip the chest D-ring and then grasp the clip at your hip and release it. With a full cylinder, you may find it helpful to hold the strap with one hand while you release the hip clip.

Removing a stage/deco cylinder is essentially the reverse of donning it. At the surface, some divers prefer to release at the hip first.

Particularly when removing stage/deco bottles at the surface, you may find it easier to release the hip clip before the chest clip. It really doesn't matter which way you do it, provided you can do so smoothly and effortlessly.

Staging Cylinders. If you're staging cylinders to retrieve later (whether stage cylinders or decompression cylinders), the entire team stages together. Place the cylinder some place stable, where it won't roll or slide, ideally securing it to something. Reconfirm that the valve's closed so that a regulator freeflow or leak can't drain it while you're gone. Leave it lying so the second stage stays out of the mud/or sand. **You and your team mates should check each other's bottle labels to be sure you're staging the correct cylinders.** If you're wearing stacked cylinders, the one you stage first should be on top.

As you practice donning, removing and staging cylinders, initially you'll do this on the bottom. But you want to learn to do so off the bottom while swimming and while hovering. You do this first to avoid silting out the water, and second to save time. You'll practice staging on the fly, where you remove and replace the cylinder while swimming, pausing only long enough to place or recover it. You'll also practice doing so while hovering, such as when you switch cylinders while decompressing.



If you're staging cylinders to retrieve later, the entire team stages together.

Whether hovering or swimming, start neutrally buoyant. When you release a cylinder to stage it, you'll become a bit more buoyant, so simultaneously deflate your BCD a bit to compensate. When picking up a cylinder, you become more negative, so you simultaneously inflate your BCD to compensate. This takes a little practice, but you'll be able to stage and retrieve with no appreciable buoyancy change.

When ascending to a deco stop, if you're close to your bottom time and your first stop is shallower than where you staged your deco cylinder, don't get behind your ascent time by donning at the staged depth. Simply grab the cylinder and clip it to an upper clip to chest D-ring as you continue upward.

Staging and retrieving on the fly – After you're comfortable donning and removing cylinders stationary, learn to do so while continuing to swim. Begin removing the cylinder as you approach the stage point so you can stop, stage and secure it quickly.

When retrieving a cylinder, pick it up and continue swimming (if it's not your stop depth) as you put cylinder on. When ascending to a deco stop, if you're close to your bottom time and your first stop is shallower than where you staged your deco cylinder, don't get behind your ascent time by donning at the staged depth. Simply grab the cylinder and clip it to an upper clip to chest D-ring as you continue upward. Don completely after reaching your decompression stop depth.

Gas Switches Underwater

Earlier you learned that switching from one gas blend to another with more oxygen, or to 100 percent oxygen, is a primary tool for efficient decompression and for gas-switch, extended no stop dives. It's one of the most important tools you have as a tec diver, and one of the primary skills that separate technical diving and recreational diving.

However*, one of the most common preventable causes of technical diver deaths is switching to the wrong gas (too high oxygen) for the depth.* When this happens, the diver often convulses from a CNS hit and drowns. To prevent this, apply the following guidelines as much as possible. Not all are possible on all dives, but some are possible on all dives:

1. Most effective guideline: *When feasible, never take a cylinder deeper than you can safely breathe from it*. But, for decompression you must be certain that your return and ascent will bring you back to your cylinders for retrieval. If getting disoriented or swept into current are realistic possibilities, as in open ocean wreck dives, etc., then don't leave them behind. In controlled conditions such as springs, lakes, quarries, tec., leaving your deco bottles at their maximum depth to pick up later is very feasible.
2. *Personally* analyze your gas and mark your cylinders.
3. Block the regulator mouthpiece on cylinders that you can not breathe from safely, so that you must remove the block before using it. This is especially important if you must take the cylinder deeper than the gas' maximum depth.
4. Follow the *complete* gas switch procedure, step by step, without cutting corners. The whole point of having a procedure is so you don't accidentally do something fatally stupid.
5. Never get complacent about staging and gas switches — pay close attention to what you're doing. Don't get distracted. *Think* about what you're doing.

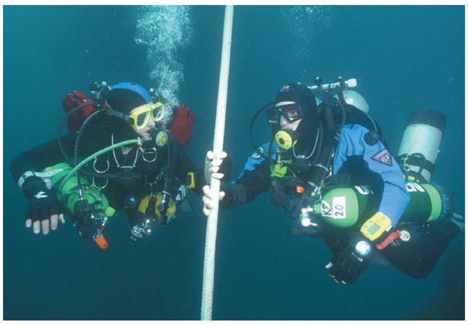
The first step in a NO TOX gas switch: Note the gas you're switching to and its maximum depth by checking the labels.

NO TOX Gas Switch. Ready for another acronym? (Okay, this one technically, isn't an really an acronym either.) Here's one that will help keep you alive by taking your through the steps of a proper gas exchange: **NO TOX**. Typically, you're already wearing your deco cylinder before you switch to it — if you staged it, you retrieve and don it first. Then, the NO TOX steps go like this:

When you switch off your back gas, clip your long hose second stage to your right chest D-ring. This keeps it from unwinding and getting tangled.

1. **N – N**ote your name and the maximum depth on the cylinder labels (if picking up a staged cylinder, you may do this as you retrieve the cylinder).
2. **O – O**bserve the actual depth and compare it to the maximum depth on the label.
3. **T – T**urn on the valve. Check the cylinder pressure.
4. **O – O**rient the second stage by pulling it from the retaining bands, and tracing the hose from the first stage to the second so there's no doubt you have the right one. Unblock the mouthpiece (if using a block), test purge the regulator and then switch to the new gas.
5. **X – eX**amine your team mates — follow the hose from their mouths to the cylinders and confirm that they're not deeper than the maximum depth labeled. If necessary, signal to confirm that you have switched (point to second stage in your mouth and then the cylinder you're using.)

When you switch off your back gas, clip your long hose second stage to your right chest D-ring. This keeps it from unwinding and getting tangled. Remember that the clip should have a breakaway connection for hand off without unclipping in an emergency.



If you're using stacked cylinders, like the diver on the right you always breathe from the top cylinder, so you would remove the top cylinder and move it underneath before NO TOX switching. Or, you simply clip the previous cylinder to your hip D-ring by the top clip and let it dangle out of the way, which is faster.

If you're switching from another stage or another deco cylinder, go to your back gas momentarily, close the first cylinder valve, retuck the second stage hoses into the bands, and then go through NO TOX as you switch to the new cylinder. If you're using stacked cylinders, you always breathe from the top cylinder, so you would remove the top cylinder and move it underneath before NO TOX switching. Or, you simply clip the previous cylinder to your hip D-ring by the top clip and let it dangle out of the way, which is faster.

Switch to your back gas as you NO TOX switch from one decompression cylinder to the next.

If you stage your deco cylinders, not taking them deeper than you can breathe them, you should retrieve each as you return to the stop depth where you'll NO TOX switch to and use each. This simplifies things if you're stacking cylinders because the new cylinder goes on top; you switch to back gas, don the new cylinder and then NO TOX switch to it. If you're wearing cylinders right and left, you'll be breathing from the left (lean gas) and can stay on it while donning the right (rich gas) cylinder. But, you should switch to back gas and shut down and stow the left cylinder before NO TOX switching to the right.

Tec Exercise – 2.5

1. The most important skill you need for decompressing is precise _________ __________ and the ability to ________ _________ for extended periods.

2. When decompressing, the ideal body position is as _______________ as possible, with the stop depth at about _______ ___________ level.

3. The proper ascent rate on a decompression dive is
   - ☐ a. 3 metres/10 feet per minute
   - ☐ b. 10 metres/30 feet per minute
   - ☐ c. 18 metres/60 feet per minute
   - ☐ d. None of the above.

4. When donning a stage/deco cylinder, most divers find it easiest to clip to the _______ D-ring first.

5. If you stack stage/deco cylinders, the one on top is
   - ☐ a. the one you breathe from.
   - ☐ b. the one you stage first.
   - ☐ c. Both a and b.
   - ☐ d. None of the above.

6. When you stage a cylinder, it's important to leave the valve open so that the regulator stays pressurized and cannot flood.
   ☐ True ☐ False

7. One of the most common preventable causes of technical diver deaths is _________ ____ _______ _________ ________ (____ ______ ______) for the depth.

8. Guidelines that reduce the chance of accidentally switching to the wrong gas at depth include (check all that apply):
   - ☐ a. When feasible, don't take a cylinder deeper than you can safely breathe from it.
   - ☐ b. Personally analyze your gas and mark your cylinders.
   - ☐ c. Use mouth blocks that you must remove before breathing from a cylinder.
   - ☐ d. Follow the complete gas switch procedure.
   - ☐ e. Pay close attention to what you're doing. Don't get distracted.

9. After donning the cylinder (if necessary) and switching to back gas, the first step in switching gases is to
   - ☐ a. turn the valve on.
   - ☐ b. deploy the second stage hose.
   - ☐ c. check the actual depth.
   - ☐ d. check the cylinder labels for your name and the maximum depth

10. The recall acronym for gas switches is _____ ________. It stands for:
    ___: ____
    ___: ____
    ___: ____
    ___: ____
    ___: ____

Check it out:

1. buoyancy control, maintain depth. 2. horizontal, mid chest. 3. d. The proper ascent rate is the rate prescribed by your table or computer. 4. hip. 5. c. 6. False. It's important to close the valve so a freeflow or leak can't drain the cylinder while you're gone. 7. switching to the wrong gas (too high oxygen) 8. a,b,c,d,e. 9. d. 10. NO TOX, N: Note your name and max depth on labels, O: Observe the actual depth and compare to max depth. T: Turn on the valve. Check pressure. O: Orient second stage(pull out, trace back to tank, unblock and test purge). X: eXamine your team mates — follow hose to cylinders to confirm proper gas.

Emergency Procedures II

In the last chapter you learned some basic emergency procedures, some of which you practiced during Training Dive One. You'll continue to practice and refine those skills as you continue through the course. Beginning with Training Dives Two and Three, you'll begin practicing some of the following procedures as well:

BCD Failure

If you're properly equipped, a BCD failure should irritate you more than scare you because it means you've got to abort the dive. Properly equipped, you should always be able to switch to your back up BCD and/or your dry suit for buoyancy control. With a back up BCD, deploy the inflator hose (tucked in cylinder bands or clipped behind BCD).

If the problem is a leaking inflator filling your primary BCD, disconnect the low pressure hose. Deflate the primary entirely as you switch to the back up so you don't have both inflated (even partially) at the same time.

Properly equipped, you should always be able to switch to your back up BCD and/or your dry suit for buoyancy control. With a back up BCD, deploy the inflator hose.

Besides going to your back up BCD or dry suit, you may be able to use an ascent line or sloping bottom to control your depth while you regain control. If you're overweight, you can drop weights (if you're wearing any) and/or no longer needed stage/deco cylinders or other equipment, but this should be a last resort only because it may make it difficult to maintain your decompression stops (it depends on your kit).

Another option is to continue to use the malfunctioning BCD (but not if you're using a back up BCD, of course). Most BCDs will hold a good bit of gas even with a leaking deflator or puncture, provided the deflator's held low or that a puncture isn't at the top. With restrained wings, it may help to cut or release the bungees (if possible). If the malfunction was a leaking inflator that you disconnected, use oral inflation as you abort the dive.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the emergency procedures for having your BCD fail?
2. What should you do if you experience symptoms of CNS oxygen toxicity?
3. What should you do if you see a team mate breathing an unsafe (too high oxygen) gas for the depth?
4. What should you do if your team mate convulses underwater?
5. What should you do if you experience difficulty maintaining your depth?
6. What is the general procedure to follow if you're unable to return to your planned ascent line?
7. How do you deploy your lift bag and reel for use as an emergency decompression line?
8. What do you do in an emergency decompression situation if your lift bag fails?

Oxygen Toxicity

As you recall, VENTID — vision, ears, nausea, twitching, irritation, dizziness — prompts the symptoms of CNS oxygen toxicity and may precede a convulsion. Unfortunately, there are usually no symptoms preceding a convulsion, so you can't count on them to warn you — you need to stay well above 1.4 ata - 1.6 ata and monitor your oxygen exposure.

If you do experience CNS symptoms, immediately switch to your back gas, which should be your lowest oxygen gas. If you're using back gas at depth, immediately ascend. Check your depth and reconfirm that you're breathing the right gas — you may have unknowingly descended below the maximum depth for the blend.

Stay on back gas for at least 15 minutes *after all CNS symptoms subside* before returning to your higher oxygen gas at its maximum depth — and only do that if you must for decompression. Otherwise, don't switch back until *shallower* than the maximum depth. If you're using high oxygen gas for conservatism, you can stay on your back gas to complete your deeper stops. If you're following an accelerated decompression schedule, don't count the time on back gas as decompression. On gas-switch, extended no stop dives, if you experience CNS symptoms, switch to back gas, ascend immediately and abort the dive (again, the inherent risk reduction advantage of staying within the no stop envelope).

When in doubt, ascend and get your PO_2 below 1.3, or lower if feasible. Oxygen is a less forgiving gas than nitrogen — better to increase your risk of DCS (which is usually treatable) than to have a substantial risk of convulsing and drowning (which is usually fatal). If you must skip stops to ascend, extending the shallower stops may keep your DCS risk down.

Team Mate Breathing Wrong Gas

Imagine you're at 18 metres/60 feet and you're completing the NO TOX switch to EANx50. You get to X — eXamine your team mate — and follow the hose from your mate's mouth to . . . oh my gosh . . . the wrong cylinder! Somehow your mate has made a major blunder and is breathing *pure oxygen*!

You can lecture later about following proper procedures (which obviously didn't happen), but what do you do now? Signal? Seconds count — what if your team mate doesn't get it? Delay.

It may seem extreme, but with time critical in this situation,

If your team mate is breathing the wrong gas, pull the second stage from your team mate's mouth and provide your long hose.

don't waste time trying to signal. *Immediately* pull the second stage from your team mate's mouth and provide your long hose. Your team mate switches and stays on back gas (yours or switches to own) until establishing the correct cylinder and sorting out the problem.

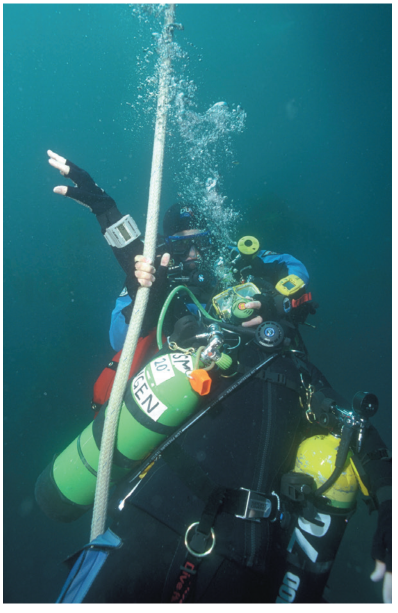
Again, NO TOX procedures avoid this problem in the first place.

Team Mate Convulses Underwater

If a team mate convulses underwater, the immediate concern is drowning. Like any rescue situation, how you deal with it depends on the circumstances and the resources you have at hand. These vary so much that there's no way to have a "standard" procedure; you'll have to consider your options and respond the best you can given the situation. And as noted in the last chapter, a diver wearing a full face mask has a much lower drowning risk. Although they're neither feasible nor common in most tec diving circumstances at this writing, that may change with the availability of new designs.

If possible, hold the second stage in the diver's mouth during the convulsion to minimize drowning risk, but if it comes out, you're not likely to be able to replace it. If your team mate begins to sink, switch to back gas before assisting so you don't risk CNS oxygen toxicity if you must descend in the process. Take care of yourself first, because if you get into trouble, you can't help and you divide the remaining resources between yourself and the original victim.

The priority is getting the diver to the surface, but doing this may or may not be a simple matter, especially if you have a decompression obligation. If you have support divers, they can take your team mate to the surface and initiate rescue breathing, CPR etc. as appropriate. It's worth noting that when taking a convulsing diver to the surface (you or the support divers), the general recommendation is to wait for the convulsion to cease and then bring the victim up, maintaining a neutral head position that allows air to escape from the airway. It's recommended that rescuers don't drop the



If a team mate convulses underwater, the immediate concern is drowning. Hold the regulator in, if possible, with the general recommendation to wait for the convulsion to cease before beginning the ascent. However, getting the victim to the surface is the priority.

victim's weights before reaching the surface, because they may lose control of victim and put themselves at risk.

Lacking support divers, if you're near the end of your decompression or didn't have a long decompression to begin with, your DCS risk is minimal, especially if you've been following a conservative profile. This is especially true if using high oxygen to pad a single gas table or computer; the higher the oxygen above what the computer/table calculations assume, and the longer you've been decompressing, the lower your DCS risk.

If your risk is high, such as if you have a long hang ahead and haven't started it, your options become more limited. If there's assistance at the surface, surface personnel may be able to help. Even if there's no one at the surface, this may still be the best you can do.

If your DCS risk appears moderate, you may choose to risk getting DCS, which is usually treatable, in exchange for a chance (not certainty) of saving or restoring your mate's life. This is *your* decision — not that it's always an easy one.

Note that without support divers, or at least some surface support, handling a team mate who convulses (or becomes unresponsive for any other reason) becomes more complicated as decompression gets longer. In this situation, you might consider planning your dives so that your team never exceeds 1.4 ata, even during decompression.

Difficulty Maintaining Depth

Earlier you learned that buoyancy control and the ability to maintain depth for an extended period is one the most important skills for decompression. Therefore, circumstances that interfere with depth control, such as sudden BCD failure, down/up current, unexpected weight loss or gain from equipment dropped or taken, etc., have a higher consequence than when in a no stop situation.

Your first response, if possible is (obviously) to grab a line or anything else to steady your depth while you regain control. This is one reason why it's preferable to decompress along a weighted line, on the bottom, etc., rather than hovering. If this isn't possible and you begin to descend, switch to back gas to avoid oxygen toxicity (don't count "sink" time as decompression time). If you begin to ascend and you can't hold on to something, you may need to exhaust your BCD and/or kick downward. If you ascend above your stop depth momentarily (less than a minute) quickly return, add a minute to the stop and resume your decompression (don't count the time above it). As a precaution, it's also a good idea to extend your last stop five to 10 minutes (or more).

You've already learned the procedures to follow if the problem lies with your BCD. If it's not your BCD, such as being underweight, get team mates to give you weight, such as stage/deco cylinders they're through with. Support divers may be able to assist by fetching weight.

Remember that it's critical to maintain depth while decompressing — do not take this problem lightly.

TWO

Unable to Return to Ascent Line

In many environments, it's reasonably likely that you won't be able to return to the ascent line. For instance, your team may get disoriented or carried down current and have to surface before regaining the ascent line. This is so common in some environments that you don't even *plan* to return to your ascent line. Obviously, in these conditions you either don't stage your decompression gases, or stage them only a short distance away where there's virtually zero chance of not recovering them, so there's no question that you'll have them when your team ascends. Note that because a boat may have to leave its anchor line or moor for any number of reasons, in tec diving it's seldom appropriate to stage deco tanks by hanging them from lines under the boat.

To ascend away from your planned ascent line (or, you may simply plan to follow this procedure), your team deploys a lift bag. The team ascends along the lift bag line and completes decompression together adrift, with the dive boat following or watching, planning to pick you up when you complete your decompression. Part of your dive plan needs to include coordinating the procedures for doing this with the boat crew and surface support.

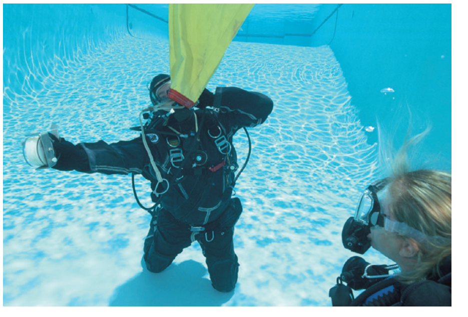
Deploying a Lift Bag. When sending up a lift bag (which you'll practice several times throughout the course), you want to get it as full as possible, control its ascent, maintain buoyancy control and avoid tangling or jamming the reel, all at the same time. No worries — do this:

1. Retrieve bag and reel. Put a puff of air in it so it floats a bit for easy handling and secure the reel line to bag clip with a double loop.

Begin lift bag deployment by putting in a small puff of air and attaching your reel.

2. Hold the reel out away from you in your extended right hand, visible, with the line tight to the bag in your left. Have the reel unlocked, but keep it from turning with your finger. Bring the bag to your mouth with the opening above your second stage and inflate it as full as you can by "puffing" your second stage in your mouth. This technique avoids entanglement, and it avoids freeflow by using the second stage that's in your mouth. You don't want the reel clipped to you because if it jams, you'd go for an unwanted ride!

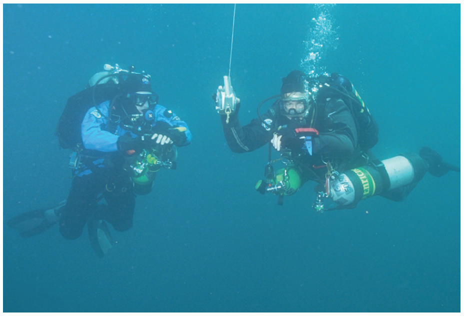
3. At the same, if you can, hold on to something with your legs, or have your team mates hold you down, so you fill the bag as much as possible without it carrying you upward. The more you fill it, the better.



Puff the bag as full as you can from your second stage (still in your mouth) with the reel unlocked and extended away from you where you can see it. This avoids entanglement.

4. Release the bag and allow it to ascend while maintaining some drag and tension on the reel so it doesn't topple and spill at the surface. Maintain tension during your ascent and decompression, or it may spill and sink.

5. After it reaches the surface, pull in and take up slack to make as vertical as possible. Your bubbles tend to push it, so don't expect it to maintain your depth — you have to do that with buoyancy control.



When decoing under a lift bag, you won't be able to hang on to the line to maintain your depth. Instead, you use it as a reference and maintain depth with good buoyancy control.

If Your Lift Bag Fails. If your lift bag fails for some reason, another diver on the team deploys the next one (every team member is supposed to have a bag, right?). If your bag went up but it's not buoyant enough, you can clip a team mate's bag to yours with a carabineer and send it up the same line — this adds buoyancy without the entanglement possibilities of another line. In some cases, the team sends up a second bag on the line to tell surface support that the entire team is there.

If your bag fails and there's no other bag available (due to separation from your team, for example), reel your bag in and try again

— it may have simply spilled. If that doesn't work, you'll have to decompress by hovering and watching your depth. When you surface, deploy your inflatable signal tube so the boat can find you more easily. Note that some inflatable signal tubes are designed to double as lift bags that you can use as back up.

If your bag went up but it's not buoyant enough, you can clip a team mate's bag to yours with a carbineer and send it up the same line — this adds buoyancy without the entanglement possibilities of another line.

TWO

Tec Exercise – 2.6

1. If your BCD fails and you're properly equipped, you switch to your ______ ____ _____ and/or ______ ______.
2. If you experience CNS oxygen toxicity, you should (check all that apply):
   - ☐ a. switch to back (lowest oxygen) gas.
   - ☐ b. descend until the symptoms subside.
   - ☐ c. ascend if possible.
   - ☐ d. confirm your depth and the gas you're breathing.
3. If you see your team mate breathing an unsafe gas for the depth, you should
   - ☐ a. signal your team mate immediately.
   - ☐ b. pull the second stage out of your team mate's mouth and provide your long hose.
   - ☐ c. watch a moment to give your mate a chance to notice.
   - ☐ d. None of the above.
4. If your team mate convulses underwater, after considering your own safety the priority is getting the diver to the _______.
5. If you have trouble maintaining depth, depending on the cause you should (check all that apply):
   - ☐ a. grab a line or object.
   - ☐ b. switch to your back up BCD and/or dry suit.
   - ☐ c. get additional weight from support divers or team mates.
   - ☐ d. switch to back gas if you're descending.
6. If unable to return to your planned ascent line, the general procedure is
   - ☐ a. to ascend and decompress along a line from a lift bag.
   - ☐ b. to split the team and conduct a broad search for the line.
   - ☐ c. send up an emergency float that guides support crew to bring the line to you.
   - ☐ d. None of the above.
7. When deploying your lift bag and reel (check all that apply):
   - ☐ a. keep the second stage in your mouth.
   - ☐ b. keep the reel locked at all times.
   - ☐ c. your team mates should stay well away from you.
   - ☐ d. All of the above.
8. If your lift bag fails after deploying it for emergency decompression, your first option is
   - ☐ a. to have another team mate deploy the next one.
   - ☐ b. to use an inflatable signal tube as a back up.
   - ☐ c. to decompress while hovering and watching your depth.
   - ☐ d. to resume your search for the planned ascent line.

Check it out:
1. back up BCD, dry suit. 2. a,c,d. 3. b. 4. surface. 5. a,b,c,d. 6. a. 7. a. 8. a.

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan a theoretical dive by calculating gas requirements, maximum depths, exposure suit requirements, methods for meeting an objective, and other particulars based on information provided by the instructor, including but not limited to a decompression schedule, SAC rates, gas blends available, the objective and details about the environment.
2. Explain the basic features of a desktop decompression software.
3. Working within your assigned team, rig stage/deco cylinders according to the methodologies described in Knowledge Development Section Two.

Preview: Practical Application Two

Practical Application II continues your gear rigging skills and begins developing your dive planning skills. You'll continue to work in a team and accomplish three tasks. Chances are, your instructor will assign these for your team to complete independently, and then evaluate your work later (such as when meeting for Training Dive Two).

Dive Planning

Your instructor will provide SAC rates to use and a dive schedule (depth, time, deco schedule) based on a single gas table/computer. You'll assume that you'll use EANx blends to make the schedule more conservative, and your instructor will tell which blends might be available for your selection. You'll also be told about the dive conditions (clarity, current, temperature), etc., the dive objective and the availability of surface support.

Applying what you've learned about gas supply planning and A Good Diver's Main Objective Is To Live, your team will provide the instructor with a written plan detailing:

- Gas requirements for each diver and gas, including one-third reserve.
- Description of all equipment required, including types and numbers of cylinders for each diver, and markings (names, max depth, etc.) on each cylinder.
- How you'll accomplish the objective.
- Logistics, including emergency procedures specific to the environment, conditions and task.

Desk Top Decompression Software Orientation

This part is fun. You and your team will open and play with one or more types of desk top deco software (if available). Your instructor will show you how to start the programs, how to get help and provide basic instruction. Your goal is to get the feel of the programs, what they do and their features. Don't worry about creating tables, though you certainly may if you want to. If such software isn't available, your instructor will refer you to web sites, provide articles, example tables, etc. to guide you to this information from various sources.

Equipment Rigging

Working within your team, you'll assemble two stage/deco cylinders per diver as you just learned about. In configuring them, try to think "package" — that each cylinder should be compact, have nothing dangling and yet be easy to handle, deploy and use. Your instructor will examine the cylinders and give you tips and suggestions as needed.

Preview: Training Dive Two

Performance Objectives

To successfully complete this training dive, the you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure.
2. Working in a team, perform a bubble check, descent check and S-drill.
3. Independently don, remove and redon a stage/deco cylinder on the bottom.
4. Independently stage a stage/deco cylinder and retrieve and redon it according to the previously described procedures.
5. Perform gas switches to stage/deco cylinders correctly following the NO TOX procedure.
6. Shut down both manifold valves and the isolator valve, switching second stages to maintain a breathing supply, beginning with any valve chosen by the instructor, within 60 seconds (or within 40 seconds if no isolator valve).
7. Deploy a lift bag from the bottom in water too deep to stand up in.
8. Swim at a steady pace at a constant depth for sufficient time to determine the SAC rate.
9. Remove and replace stage/deco cylinders at the surface in water too deep to stand in.
10. Demonstrate time, depth and gas supply awareness by writing the depth and SPG reading at the 15 minutes bottom time mark.

Predive briefing and gearing up

Training Dive Two

- At 15 minutes bottom time, write SPG reading on your slate.

Entry

Weight check (if needed)

Bubble check

Descent

Descent check

S-drill

Don, remove and redon stage/deco cylinder

Stage and retrieve stage/deco cylinder

NO TOX gas switch

Stage cylinder

Gas shut down drill — close and reopen both regulator valves and isolator valve, switch second stages to stay with the open valve, within 60 seconds

Retrieve cylinders, NO TOX gas switch

Deploy lift bag — switch to back gas, then send up bag

SAC swim

Free time for fun and skill development

Ascent

Remove, replace and re-remove stage/deco cylinder at the surface

Recheck weight (if necessary)

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Preview: Training Dive Three

Performance Objectives

To successfully complete this training dive, the you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure.
2. With minimal assistance, don two stage/deco cylinders at the surface in water too deep to stand in.
3. Working in a team, perform a bubble check and descent check.
4. Stage and retrieve two stage/deco cylinders, making NO TOX gas switches.
5. Maintain a simulated decompression stop for three minutes while breathing from a stage/deco cylinder.
6. Stage, retrieve and replace two stage/deco cylinders while continuing to swim.
7. With minimal assistance, remove and replace two stage/deco cylinders while wearing no mask.
8. Respond appropriately to a team mate simulating switching to the wrong gas underwater.
9. Perform the previously learned gas shutdown drill within 60 seconds.
10. Deploy a lift bag from the bottom in water too deep in which to stand.
11. Swim at least 18 metres/60 feet sharing gas with the long hose as both a donor with a mask, and as a receiver without a mask.
12. Determine SAC rate by swimming at a slow, steady pace with a stage cylinder at a level depth for suffiicent time, recording all the required information for subsequent calculation.
13. Tow a simulated unresponsive, breathing diver horizontally 6 metres/20 feet.
14. Perform two gas switches following the NO TOX procedure in midwater along a vertical line, with the first simulating a deeper stop and the second simulating switching gases at a shallower stop.
15. Maintain a simulated decompression stop in midwater (contact with a line, pool wall, or other vertical reference is acceptable) for 10 minutes, noting the required information for subsequently calculating the decompression SAC rate.
16. With minimal assistance, remove two stage/deco cylinders at the surface in water too deep to stand in.
17. Demonstrate depth, time and gas supply awareness by, upon reaching the back gas SPG pressure assigned by the instructor before the dive, writing the depth and time on a slate.

Predive briefing and gearing up

Training Dive Three

- Upon reaching the SPG pressure designated by your instructor, write the bottom time and your depth on your slate.

  Entry

  Weight check (if necessary)

  Bubble check

  Don two stage/deco cylinders at the surface

  Descent check

  S-drill (optional at instructor's discretion)

  Stage and retrieve stage/deco cylinders making NO TOX gas switches

  Hover for three minutes

  Stage cylinders, retrieve and replace on the fly.

  Remove and replace both stage/deco cylinders with no mask.

  Team mate goes to wrong gas drill

  Gas shutdown drill — within 60 seconds

  Deploy lift bag

  Long hose gas sharing, no mask swim

  SAC rate swim

  Unresponsive diver tow

  Midwater (on line) NO TOX gas switches

  10 min SAC rate midwater "deco stop"

  Free time for practice and experience

  Ascent

  Remove stage/deco cylinders at the surface.

  Weight recheck (if necessary).

  Exit

Post Dive

  Performance review

  Disassemble and stow equipment

Log dive for instructor signature.

Assignments

KNOWLEDGE Review – Chapter Two

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. Describe a suitably rigged stage/deco bottle "package."

2. Briefly list the guidelines regarding material and equipment compatibility using enriched air and oxygen. What do you risk if you fail to follow these?

3. Explain how you determine your required decompression stops using a single gas computer or table, and how to use switches to enriched air or oxygen to make the decompression more conservative.

4. What is a gas-switch, extended no stop dive?

5. What do you assume your END is with enriched air? Why?

TWO

6. What is the “ideal” gas blend for a dive to 25 metres/83 feet?

7. **Metric** – You plan to make a dive with air by following a standard air table. You plan to make the decompression more conservative by using EANx36 at 9 metres, and EANx80 at 6 metres and 3 metres. Your planned dive is 40 metres for 40 minutes, with 1 minute required at 12 metres, 8 at 9 metres, 17 at 6 metres and 46 at 3 metres. Your SAC rate is 21 litres per minute during the working part of the dive, and 16 litres per minute when decompressing. Your ascent rate is 10 metres per minute. What are your total gas requirements for each gas, including a one-third reserve?

   Air =

   EANx36 =

   EANx80 =

Depth	Time	SAC	Con. Fctr	Volume	Gas

7. **Imperial** – You plan to make a dive with air by following a standard air table. You plan to make the decompression more conservative by using EANx36 at 30 feet, and EANx80 at 20 feet and 10 feet. Your planned dive is 130 feet for 40 minutes, with 1 minute required at 40 feet, 8 at 30 feet, 17 at 20 feet and 46 at 10 feet. Your SAC rate is .7 cubic feet per minute during the working part of the dive, and .65 cubic feet per minute when decompressing. Your ascent rate is 30 feet per minute. What are your total gas requirements for each gas, including a one-third reserve?

   Air =

   EANx36 =

   EANx80 =

Depth	Time	SAC	Con. Fctr	Volume	Gas

8. What are the advantages and risks of using desk top decompression software?

9. What should you assume about every technical dive, and what should you take for granted?

10. What is your most important resource in a tec diving emergency, and what provides this resource?

11. What is the principle of your gas reserves and how do you apply it during an open water technical dive?

12. What's the recall phrase for the seven segments of planning a tec dive, and what does the phrase stand for? List substeps for each of the segments.

TWO

13. Why do all team members on a technical dive usually use the same gases?

14. What four markings should be on every cylinder used on a technical dive? Which should be easily read by your team mates while wear the cylinder? Why are these markings required?

15. Who must check the pressure and oxygen analysis of every cylinder used in a technical dive?

16. What is the predive check recall phrase in tec diving? What does it stand for, and what steps does the predive check include?

17. What is your one-third turn pressure if you have 190 bar or 2800 psi in your cylinders?

18. Describe how to perform a bubble check and a descent check.

19. The thumbs up signal means

20. What's the ideal position and stop depth level when decompressing? What is the most important skill you need for decompressing?

21. What is one of the most common preventable causes of death in technical diving?

22. List five guidelines that reduce the chance of accidentally switching to an unsafe gas blend at depth.

 1.____
 2.____
 3.____
 4.____
 5.____

23. What's the recall acronym for gas switches? Describe the gas switch procedure and how the acronym prompts you.

24. Describe what to do if you experience possible symptoms of CNS oxygen toxicity.

TWO

25. What should you do if you see a team mate breathing an unsafe (too high oxygen) gas for the depth?

26. What should you do if a team mate convulses underwater?

27. What is the general procedure if you can't return to your planned ascent line?

Student Diver statement: I've reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date __________

Challenge
is one of the essential nutrients of human growth. Many years ago I discovered that exploring the undersea world and its dominions is a splendid summons of physical and mental energies. Living safely within the ocean's harsh physical and chemical laws demands exquisite harmony between mind and body.

— **Dr. Joe MacInnis**, Canadian Scientist and underwater explorer, *Underwater Man*, 1974

THREE

Chapter THREE: The Structure

Chapters One and Two established the foundation and the basic framework for becoming a tec diver; now you'll be adding structure. You start off with the final details about tec *diving equipment*, then head into your third discussion on *gas planning*. This really puts it together because you'll be calculating your gas supply requirements and oxygen exposure for decompression dives. You'll need your calculator.

From there you jump into more emergencies and what you should do when what can go wrong does. Then you'll look at some more *techniques* you'll be practicing and applying during your training dives, especially during planning and the A Good Diver's Main Objective Is To Live steps. The next team diving discussion shows you some new signals and the team's role as "back ups," followed by more on *thinking like* a tec diver, which among other topics, summarizes the six principles for surviving a tec dive. The chapter finishes up with an overview of Practical Application Three and Training Dives Four and Five.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are three reasons that technical divers consider a slate standard equipment?
2. What is a "jon line" and how do you use it?
3. What benefits does a multigas computer offer you?
4. What are the options regarding urination for long technical dives?

Equipment III

Slates. In recreational diving, many divers consider slates a convenience. You've probably been on a group dive where someone wanted a slate, and it became a game to see who, among half a dozen divers, actually had one.

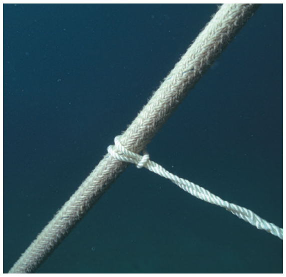
In tec diving it's another story. Slates become mandatory equipment for three important reasons. First, you use it for communication (true in recreational diving, too) when understanding is crucial and signals don't do the job. Second, as you've noticed there's a lot you need to keep track of on a tec dive, and you don't want to trust your well being to memory. You write down and take with you key information, such as your decompression schedule, reserves, the pressure when you have to start up (turn pressure), maximum time and depth, and so on. Finally, you record your time, depth and gas supply throughout a dive for tracking, for comparison against the dive plan, and for calculating SAC rate, etc.

Choose a slate that fits easily in your thigh pocket (or whatever pocket you have that's easy to get to.) You'll be using it a lot, so be sure you can grab it and return it easily. Although your basic slate does the job, a good choice is a multiple-page slate for lots of writing space. You'll also find specialized slates for dive planning, surveying, etc. handy.

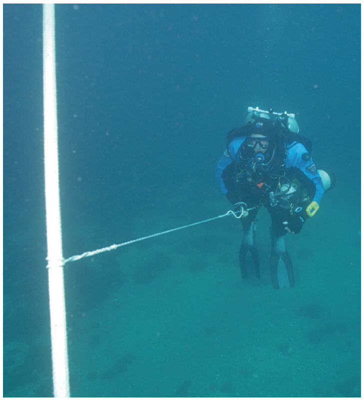
Although your basic slate does the job, a good choice is a multiple-page slate for lots of writing space.

Jon Line. Under "crowded" in the dictionary they should have a picture of six tec divers doing a hang at the same depth on the same anchor line in a current. Everyone's trying to be at the right depth, and with a current, the tendency is for everyone to get pushed around into the same place (hence why drift hangs are popular when possible). It's also tiring.

Named for Jon Hulbert, who popularized their use, a *jon line* is a short line, about a metre/three feet to three metres/10 feet long that you loop or hook around the anchor line and then clip to your harness. It lets you hang floating back away from the crowd, and saves effort since you don't have to hang on. It opens up space for other divers, and it reduces the chance that you'll get blown off the line and have to finish your deco drifting under your lift bag. They're so advantageous if you have to hang in a current that some divers carry two, just in case they accidentally lose one while deploying it.



The jon line secures to the anchor or mooring line with a clip, or with a loop snugged down on the line as shown.



A jon line is a short line, about a metre/three feet to three metres/10 feet long that you loop or hook around the anchor line and then clip to your harness. It lets you hang floating back away from the crowd, and saves effort since you don't have to hang on.

Multigas Computers. Chapter One introduced you to multigas computers and you've been reading a bit about them in various other discussions up to this point. They're definitely the trend in tec diving — by the time you read this, they may even be standard equipment.

As you learned in Chapter One, with multigas computers you don't have to base your decompression schedule on a single gas blend. Instead, you preprogram them with three (or more) gases, and then tell them which one you're using throughout the dive. This has numerous benefits.

1. You can make gas-switch, extended no-stop dives with substantial no decompression time. This means that when you ascend and switch to a higher oxygen gas, you get more time due to your multilevel profile and due to breathing less nitrogen. For example, you're diving with air and have a stage cylinder of EANx40. After 15 minutes at 30 metres/100 feet, you ascend to 18 metres/60 feet. Your computer says you have 12 minutes no stop time. Better than nothing, but hardly worth it. Switch to EANx40 and press the button telling the computer you did and presto — the number jumps to 100 minutes. Now *that's* worth it — probably more time than you have EANx40, and it's a no stop dive.

2. Similarly, you can enjoy accelerated decompression, which Chapter Two introduced, to reduce your hang time. As you learned, breathing a higher oxygen gas (or even better, pure oxygen) causes dissolved nitrogen to diffuse from your tissues much faster than if you stayed on a lower oxygen gas. This means your decompression is shorter. In practice, for example, you might be diving with air to 40 metres/130 feet for 30 minutes. You head up and your computer says you have 16 minutes of deco starting at 6 metres/20 feet. You get to 6 metres/20 feet, switch to oxygen and punch that into your computer. Blip! The 16 minutes changes to seven minutes. That's the benefit of oxygen — you can do this with any higher oxygen

enriched air (the higher the oxygen percent, the more time you save), but once you reach 6 metres/20 feet, pure oxygen is the optimum gas for accelerating your decompression (and it has other benefits — more about this later on).

3. You don't need to calculate oxygen exposure manually as you do when making gas switch dives using a single gas computer. As you switch gas blends, the computer tracks how that affects your oxygen exposure.

4. They simplify some contingency situations. Suppose you're decompressing and pow! The deco cylinder's second stage hose ruptures. You shut it down and switch one of your other regulators to it, but the rupture blew away too much gas. You run out before you can finish the last decompression stop you were supposed to make with that gas. Now what? Switch to your back gas (plenty of that left) and punch that into the computer. The computer gives you the new, longer time to finish the stop using back gas.

Multigas computers offer a lot of flexibility, but they do cost more, and some *require* desk top decompression software. (That's not a huge disadvantage in that you're going to want desk top deco software anyway.)

Urination. Technical deep dives tend to be long dives — two or more hours isn't unusual — making a minor issue in recreational diving into a real issue for tec divers. That's having to urinate, which is an especially big issue wearing a dry suit. At this writing there are three options for handling this problem, only two of which females can apply.

The first is to wear a wet suit and to well, just go when you need to. You'll want to wash the suit thoroughly after the dive, needless to say, but it won't hurt you or the suit.

The problem with the wet suit approach is that it's really only a fairly warm water choice. Often the temperature's such that a wet suit will do the job for a brief no stop dive, but for a long tec dive you need to go dry. Secondly, if you're just barely staying warm enough, relieving yourself in your wet suit may make you cold. This is because warm fluid dilates skin capillaries and increases blood flow to the skin, where it loses heat rapidly. It feels warm, but the warmth you feel is your body heat going into the water.

In a dry suit, one option is adult diapers. They're inexpensive and you don't have to modify your dry suit — and they're really the only option for females (at this writing). Unfortunately, they only hold a limited capacity, after which they're soaked and will leak. Also, they can't absorb a lot at once; you have to relieve yourself slowly or it will leak into your suit. Nonetheless, many divers find them suitable for dives up to three or four hours long. They're also a good option in pristine environments in which it is inappropriate to urinate into the water.

Males can use disposable condom catheters that route waste outside the suit through a tube and valve. The big advantage is that this is a limitless option — you can use it as much as needed. The first downside is that you have to have the valve installed, and that you have to know how to use it. Most require you get into a face-down position before you open the valve, or you risk a squeeze where you don't want one (no, this isn't a joke). They're a bit tricky to hook up and take apart (you need some privacy), and they require maintenance (follow the manufacturer's guidelines). But, many divers will tell you that one hour into a two hour hang, if you need it you'd happily put up with twice the hassle.

Males can use disposable condom catheters that route waste outside the suit through a tube and valve. You open the valve to relieve yourself and then screw it shut. There are also hands-free valves available.

THREE

Tec Exercise – 3.1

1. Reasons tec divers consider a slate standard equipment include (check all that apply):
   - ☐ a. communication.
   - ☐ b. carrying key information.
   - ☐ c. recording your depth, time and gas pressure.
   - ☐ d. playing games during long hangs.
2. A "jon line" is a short cord you attach to an anchor line and your harness to make decompressing in a current easier.
   ☐ True ☐ False
3. Benefits of a multigas computer include (check all that apply):
   - ☐ a. making gas-switch, extended no-stop dives.
   - ☐ b. making accelerated decompression dives.
   - ☐ c. tracking your nitrogen narcosis.
   - ☐ d. simplifying some contingency situations.
4. Options for urination for long technical dives include (check all that apply):
   - ☐ a. condom catheter (for males) valve systems.
   - ☐ b. disposable adult diapers.
   - ☐ c. use a wet suit.
   - ☐ d. wear highly absorbent dry suit under garments.

Check it out:
1. a,b,c. d is a common use, but it doesn't make slates mandatory. 2. True. 3. a,b,d. c is not true because you can't track nitrogen narcosis; they track oxygen exposure. 4. a,b,c. d might work, but wouldn't be a good option.

Gas Planning III

This Gas Planning section starts bringing together the variables that you juggle as you plan a dive: oxygen exposure, decompression schedule and gas supply. What you're learning to do is to find the dive schedule that keeps you within oxygen limits, that provides adequate decompression to minimize DCS risk, and what the gas requirements are. They're all variables that affect your dive plan — change any one, and the others change. It's often a juggling act of finding the right combination (desk top deco software really comes in handy doing this.)

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is the theoretical cause of gas narcosis?
2. How does oxygen fit into the narcosis theory?
3. How do you account for narcosis in dive planning?
4. What depth limits arise from narcosis concerns?
5. How do you perform an "air break" and why should you do so?
6. How do you determine your OTUs and OTU limits for a given dive profile?
7. How do you calculate the "CNS clock" exposure for a given dive profile and determine its limits?
8. How do you include oxygen concerns in determining the ideal enriched air to use at a given depth?
9. What is the basis of oxygen surface interval credit, and how do you apply it?
10. What are six advantages of decompressing based on a single gas computer or table and using enriched air and/or oxygen for conservatism?

You should also be able to:

11. Calculate the gas supply requirements and oxygen exposure for a decompression dive based on a single gas computer using enriched air and/or oxygen during decompression for conservatism.

Narcosis – Theory and Application

Theory. As you learned in Gas Planning II, a tec diver using air and enriched air can't really do anything about narcosis directly because oxygen and nitrogen are both narcotic, and your Equivalent Narcotic Depth (END) does not change as you change the ratio of oxygen and nitrogen. It's worth looking at the theoretical basis for this.

The prevailing theory about gas narcosis is the Meyer-Overton hypothesis. It says that gas absorption into nerve cell lipids interferes with nerve impulse transmission, resulting in narcosis. Gas solubility varies with different gases depending on solubility; the higher the solubility, the higher the potential for narcosis.

Oxygen is *twice* as soluble as nitrogen; suggesting that it is potentially *more* narcotic than nitrogen. This is offset somewhat by your body metabolizing oxygen, however, so it doesn't appear to be necessary to raise your END with enriched air compared to air. Argon is more soluble than nitrogen or oxygen, which (along with being very dense) is why it's a poor choice as a breathing gas. Nitrous oxide, which you may be familiar with from your dentist's office, is highly soluble; essentially, you're narked at the surface when your dentist uses it.

Helium, on the other hand, dissolves very poorly into lipids. This is why more advanced forms of tec diving and commercial diving use helium in trimix (helium-oxygen-nitrogen) and heliox (helium-oxygen); it is non narcotic. However, it has other characteristics that you have to be aware of — including being relatively unforgiving decompression-wise — which is why diving with helium requires special training and super precise dive skills. Using helium, you'd be able to determine an END that's shallower than your actual depth.

Application. You must realize that narcosis is present on all dives — in theory, it begins to affect you as soon as you drop below the surface, though effects don't become noticable for most divers until approaching the 30 metres/100 foot range. Diving with some narcosis present is acceptable (and practically speaking, unavoidable), provided it doesn't impair you.

Whether it causes substantial impairment is highly variable, as discussed in a moment. Proper training allows you to function properly with some narcosis present — the use of step-by-step procedures (NO TOX switches, for example) not only speed learning, but aid proper functioning — *what seems simple at the surface may not be as simple under stress on a deep dive*. During some of the dives in this course you'll practice missions and perform timed tasks that help you recognize your response to narcosis. **Diving substantially impaired can be one of the primary hazards of deep tec diving (even when using helium blends) — so, be conservative when dealing with narcosis**. You account for narcosis in dive planning by limiting your dives to appropriate depths based on:

Safety – Your primary concern is that you note and react quickly and properly to emergencies. If you're so narked (under the influence of narcosis) that to react quickly and properly to an emergency is questionable, ascend immediately to a shallower depth. It may take some time for your head to clear.

Individual susceptibility – Narcosis affects different people differently at different times. You're more likely to be affected adversely when you've not made a deep dive recently, you're attempting new tasks and/or are task loaded, or you implement an emergency procedure you've not practiced recently. Narcosis may affect you more readily in more challenging conditions, such as in cold, dark lake versus a warm, clear tropical reef. The further you are from optimal fitness, the more likely narcosis will affect you.

Working in your favor, individual adaptation and compensation (sometimes called, somewhat inaccurately "tolerance") goes up and you'll be more able to function adequately with narcosis when you've been diving regularly, working up to the depth progressively. Narcosis becomes less of a factor when your mission and the dive requirements are not complex, when you've practiced emergency procedures extensively and regularly, and when you're diving in good environmental conditions. Good fitness seems to increase your ability to function with narcosis.

Looking at these variables, you must adjust your depth limits based on you, your team and the dive conditions. As a starting point, the technical diving community generally observes the following narcotic limits when using air or enriched air:

1. **40 metres/130 feet** — limit for recreational diving, and limit for technical penetration (cave, wreck) into overhead environments.
2. **50 metres/165 feet** — general limit for technical air diving, particularly inexperienced technical divers. Note that much of the European dive community has used this limit for decades, and it is acknowledged by organizations such as the United Kingdom's Health and Safety Executive (HSE) and the South Pacific Medicine Society (SPUMS). It also mirrors the commercial diving limit for air of 170 feet in the USA. Using this as the air/enriched air limit, along with proper training, equipment and making allowances for personal and environmental factors, has a good track record.
3. **56 metres/185 feet — 1.4** ata PO_2 limit for air diving (as well as narcosis).

Different limits apply to tec diving with helium blends.

As a technical diver, it is *your* responsibility to adjust your maximum depth based on how narcosis and other variables affect you on a dive. A dive to 50 metres/165 feet on air may be simple and acceptable in warm, tropical sea with clear water. But, the same depth in a cold, dark lake or in strong current, etc., can be a hugely different situation that may be too deep. During a dive like that, you may need to plan your dive to a shallower maximum, and perhaps actually dive shallower than that if you or a team mate find narcosis becoming too strong. *It's your responsibility to adjust according to narcosis effects because only you know how it's affecting you*. Be conservative. If you make a dive and discover you could have planned to go somewhat deeper without undue risk, and there's a reason to, you can always go back.

It is your responsibility to adjust your maximum depth based on how narcosis and other variables affect you on a dive. Only you know how depth is affecting you.

Managing Oxygen Exposure — Continued

Chapters One and Two introduced you to the basic concepts behind managing CNS oxygen toxicity and pulmonary toxicity. CNS toxicity, you're aware, is the most immediate concern because it can cause a convulsion that leads to drowning, and that pulmonary toxicity is a longer term problem you have to manage. Now it's time to go into more about preventing both types.

Air Breaks. While decompressing on oxygen or EANx at a depth that yields a PO_2 of 1.6 ata, a switch to air (or an EANx blend with a comparatively low oxygen fraction) gives your body a rest from the high oxygen exposure. This is called an *air break*; air breaks have been found to greatly reduce the risk of a CNS oxygen toxicity convulsion. You should consider them standard practice when decompressing, and you don't have to limit them to a PO_2 of 1.6 ata. Most divers perform air breaks at lower PO_2s as well.

The typical air break is five minutes on air (or lowest oxygen gas available) for every 20 to 25 minutes of decompression. You do not include the 5 minutes in your decompression time when following an accelerated decompression schedule. You may consider it decompression time when following a single gas computer or table, but using enriched air and/or oxygen to make the schedule more conservative. Some desk top deco software programs can automatically include air breaks in the tables they generate.

THREE

Calculating OTUs.

As you learned previously, the OTU (Oxygen Toxicity Unit or Oxygen Tolerance Unit — depends on the reference — introduced by Dr. Bill Hamilton as an extension of the previous UPTD [Unit Pulmonary Toxic Dose] method) is a method for measuring your oxygen "dose" for a given dive. This is one of your primary methods for tracking and preventing pulmonary oxygen toxicity. It's based on the formula:

$$\text{OTUs} = \text{minutes} \times ((PO_2 - 0.5) \div 0.5)^{0.83}$$

Boy, doesn't that look like a lot of mathematical fun. Actually, it's not that difficult, but it's much simpler and less error prone to use desk top deco software, which calculate automatically, or tables such as the Equivalent Air Depth and Oxygen Management Table. With the table, you simply multiply OTU per minute for a given blend at depth by the minutes at that depth. Round down to the next deeper depth if the actual depth isn't shown. You do this for all depths (including your ascent and decompression/safety stops) and total them to get your OTUs for the dive. Note: You accumulate no OTUs when your PO_2 is .5 ata or less.

OTU limits appear on the Oxygen Limits Table in the appendix. Note that the total OTUs allowed per day varies depending on the number of continuous days of diving. This is based on the body's ability to recover from oxygen exposure.

For example, if you're only diving for *one* day, you can rack up 850 OTUs. But then you're out of the water for a couple of days. If you're diving five days in a row, you can have a total of 2300 OTUs, or an average of 460 OTUs per day, as the maximum. Your total OTUs on any of these days may exceed 460, but, you cannot exceed 2300 for all five days combined. If the first day exposes you to 700 OTUs, you have a total of 1600 OTUs (2300-700=1600) to divide among the remaining four days.

The "Average OTUs per Day" column stands for the daily average for a mission of that length. It is not a daily allowance. That is, you cannot have 850 day one, 700 day two, 620 day three, etc. By the way, if you ever don't know what the OTU daily limit is (no table available), the daily OTU limit for continuous days forever is 300 OTUs. Limit your daily OTUs to 300 and you'll be within limits.

To calculate your OTUs and limits for a dive, total all the OTUs for each planned depth based on the gas blend and time, including your ascent and any safety/decompression stops, making sure the total is within the allowable OTUs. (After the dive, you total the OTUs for the actual dive to use in planning subsequent dives). Normally you disregard air breaks in figuring OTUs, and when your PO_2 is less than .5 ata, you accumulate zero OTUs. You get your OTU per minute using the Equivalent Air Depth and Oxygen Management Tables, by finding the blend you're using. At each depth, you find the PO_2 and OTU per minute (round to the next deeper depth if your depth isn't shown.)

Example (Metric):
You're planning three days of diving, and this is the first dive of the second day. You ended yesterday having used 705 OTUs, and you know you'll need 700 OTUs for the dives planned on the third day. You plan to dive to 30 metres on air and decompress using EANx40 at 6 metres and oxygen at 3 metres as decompression "pad" following the air-only schedule. Your planned bottom time is 40 minutes, and the tables you plan to use require 8 minutes of decompression at 6 metres and 26 minutes at 3 metres. Your ascent rate is 10 mpm. What are your OTUs for the dive? If you make only this dive today, do you have enough OTUs for tomorrow? If not, how many

more do you need? If yes, how many do you have to spare after this dive if made as planned?

Answer: 71.2 OTUs for the dive. Yes, you would have 383.8 OTUs left for the second day after this dive.

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	
									OTU Total 71.2
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	CNS Total
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Total Deco

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
30	40					Air	.84	.73	29.2		
18 (ascent)	3					Air	.59	.24	0.7		
6	8					EANx40	.64	.35	2.8		
3	26					oxygen	1.3	1.48	38.5		

THREE

Total allowed for 3 days = 1860

1860 - 705 (day 1) - 700 (day 3) = 455 OTUs available for day 2.

455 - 71.2 = 383.8 OTUs left.

Example (Imperial):
You're planning three days of diving, and this is the first dive of the second day. You ended yesterday having used 705 OTUs, and you know you'll need 700 OTUs for the dives planned on the third day. You plan to dive to 100 feet on air and decompress using EANx40 at 20 feet and oxygen at 10 feet as decompression "pad" following the air-only schedule. Your planned bottom time is 40 minutes, and the tables you plan to use require 8 minutes of decompression at 20 feet and 26 minutes at 10 feet. Your ascent rate is 30 fpm. What are your OTUs for the dive? If you make only this dive today, do you have enough OTUs for tomorrow? If not, how many more do you need? If yes, how many do you have to spare after this dive if made as planned?

Answer: 71.6 OTUs for the dive. Yes, you would have 383.4 OTUs left for the second day after this dive.

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	
									OTU Total 71.6
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	CNS Total
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Total Deco

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
100	40					Air	.85	.74	29.6		
60 (ascent)	3					Air	.59	.24	0.7		
20	8					EANx40	.64	.35	2.8		
10	26					oxygen	1.3	1.48	38.5		

Total allowed for 3 days = 1860

1860 - 705 (day 1) - 700 (day 3) = 455 OTUs available for day 2.

455 - 71.6 = 383.4 OTUs left.

Calculating the "CNS clock"

The "CNS clock" also manages pulmonary oxygen toxicity (primarily). Although it seems somewhat redundant to calculate the "CNS clock" and OTUs, this is the state of practice in tec diving that continues because it works well. You calculate the "CNS clock" much the same way you calculate OTUs — by using desk top deco software, or by using tables to determine the CNS percent per minute. Note that some programs and tables extrapolate NOAA limits to more increments on the "CNS clock" than others; this may produce some differences in what different programs and tables produce. As with OTUs, you normally disregard air breaks in calculating the "CNS clock." As with OTUs, you determine the CNS percents for each depth and time, including your ascent and deco/safety stops, and total them for your total CNS exposure for the entire dive.

You get your CNS percent per minute using the Equivalent Air Depth and Oxygen Management Tables, by finding the blend you're using. At each depth, you find the PO_2 and CNS percent per minute (right next to where you found OTU per minute); as before, round to the next deeper depth if your depth isn't shown.

Example (Metric):
You dive to 33 metres using EANx32 and for 65 minutes. The EANx32 tables you're using call for a 15 minute stop at 6 metres and 40 minute stop at 3 metres. You plan to use 100 percent oxygen at these stops to maximize your conservatism. Your ascent rate is 10 metres per minute. What is your "CNS clock" at the end of the dive?

Answer: 99.8%

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	
									OTU Total
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	CNS Total 99.8%
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Total Deco

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
33	65					EANx32	1.38			.67	43.5
20 (ascent)	3					EANx32	.99			.33	1.0
6	15					oxygen	1.6			2.22	33.3
3	40					oxygen	1.3			0.55	22.0

Example (Imperial):
You dive to 110 feet using EANx32 and for 65 minutes. The EANx32 tables you're using call for a 15 minute stop at 20 feet and 40 minute stop at 10 feet. You plan to use 100 percent oxygen at these stops to maximize your conservatism. Your ascent rate is 30 feet per minute. What is your "CNS clock" at the end of the dive?

Answer: 99.8%

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	
									OTU Total
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	CNS Total 99.8%
Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Total Deco

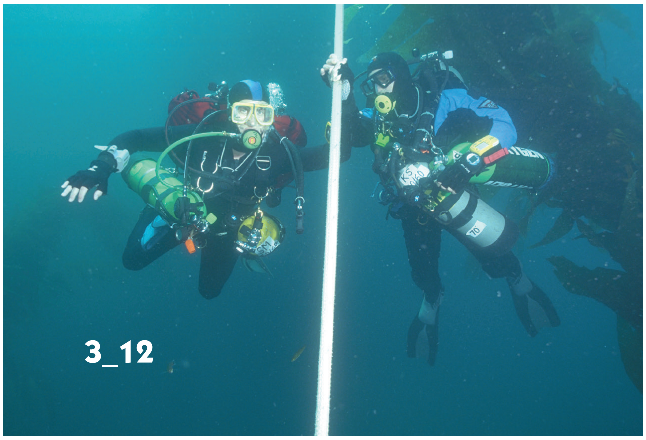
Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
110	65					EANx32	1.39			.67	43.5
65 (ascent)	3					EANx32	1.0			.33	1.0
20	15					oxygen	1.6			2.22	33.3
10	40					oxygen	1.3			0.55	22.0

Oxygen Exposure and Ideal Enriched Air Blend

You learned in the last chapter to choose the "ideal" gas based on the blend that allows the highest fraction of oxygen without exceeding a PO_2 of 1.4 at the desired depth. Pragmatically you usually work with the closest EANx blend you have available, but the idea is to maximize your no stop time or minimize your hang time within oxygen limits.

However, previous oxygen exposure can affect your gas choice if you won't have enough oxygen exposure time (OTUs and/or "CNS clock") remaining to make the dive. Therefore, you may need to choose a blend with less oxygen so you have a PO_2 even lower than 1.4.

For example, suppose that as part of a 15 day dive series during which you're keeping your OTUs within the accepted daily average (300), you plan a repetitive dive to 21 metres/70 feet for 45 minutes. At the start of the dive, your CNS clock is 80 percent and you have 240 OTUs for the day.



Remember that if your repetitive dive is a gas-switch, extended no stop dive or a decompression dive, you need to account for oxygen exposure at all levels with all gases. This is particularly important when decompressing with oxygen or EANx50 and above.

The "ideal" blend would normally be EANx45, but 45 minutes at 21 metres /70 feet yields 72.9(metric)/73.8 (imperial) OTUs and 30 percent CNS, putting you over both the CNS and OTU limits. Using EANx32, however, 45 minutes at 21m/70 ft yields 45 OTUs and 14.8% CNS, keeping you within limits.

Remember that if your repetitive dive is a gas-switch, extended no stop dive or a decompression dive, you need to account for oxygen exposure at *all* levels with all gases. This is particularly important when decompressing with oxygen or EANx50 and above; the numbers go up fast, even when you're 6 metres/20 feet deep or less.

Using desktop deco software greatly simplifies finding an appropriate gas blend for a repetitive dive with high OTUs and/or "CNS clock." Some divers use an alternate method of calculating the "CNS clock," which is to divide the actual time by the *single exposure* time for that PO_2 on the NOAA Oxygen Exposure Limits listed on the Oxygen Limits Table.

Example: In calculating a dive, you will spend 10 minutes at 30 metres/100 feet using EANx32. What is your "CNS clock" percent for that part of the dive?

Answer: 5.5%
Limit for 1.3 PO_2 = 180; 10 ÷ 180 = .055 = 5.5%

You may use this method for each level and PO_2 as an alternative to the percent-per-minute method. Both will give you approximately the same answers, though you may find insignificant variations due to rounding.

Oxygen Surface Interval Credit for the CNS "Clock"

Between dives breathing air, your body begins to reverse the chemical effects of oxygen. The OTU system accounts for this in its mission/daily average methodology. For the CNS "clock," there's surface interval halftime credit, which is operationally similar to dive table credit. CNS surface interval credit is not commonly used with recreational enriched air diving because you almost never reach oxygen exposure limits making no stop dives with EANx40 or less, so in that envelope it's not an issue.

CNS surface interval credit was initially based on studies of hospital patients undergoing long term oxygen exposure. Though not based on divers initially, the CNS surface interval credit system, when also used with the OTU system, has a good field record in diver use. Different computers, desk top deco software and tables use different halftimes for this — 90 minutes is the "standard halftime," but some default to a slightly less conservative 60 minutes (you can usually reset it higher, though).

You can apply your CNS credit several ways. Enriched air computers and desk top deco software will calculate your credit for you, but keep in mind that not all computers/programs

Oxygen Toxicity: Another Perspective

It might be hard to imagine there's a good side to the potential for oxygen toxicity, but actually, if it weren't for that phenomenon, oxygen would have significantly less decompression benefit.

Oxygen and EANx accelerate your decompression and extend your no stop limit compared to air because you've replaced some (or all) of the nitrogen with oxygen. You're taking in less nitrogen — but why is it that, with respect to decompression, we can, for practical purposes (within limits) ignore the oxygen?

The reason is that our bodies consume most of the oxygen that enters our bloodstream. However, it's not all metabolized — there's no way the body can metabolize (use in energy production) all the oxygen. Your body only needs to generate so much energy. Your body consumes the rest of the oxygen by other chemical processes going on in the body. If these processes happen too quickly or if they go on too long, you have oxygen toxicity. But within limits, these processes take most of the oxygen out of the bubble-forming category, which is why oxygen provides such a huge advantage. In a sense, without the potential for oxygen toxicity, oxygen wouldn't help tec divers nearly so much.

give credit. Otherwise, you can use a table such as the CNS Surface Interval Credit Table in the appendix.

Find your CNS percent at the start of surface interval along the side, and where your interval falls along the side. Where they intersect is your new CNS percent, which you add to the CNS percent you accumulate during the next dive. (If your percent isn't shown, round up to the next greater.)

CNS SURFACE INTERVAL CREDIT TABLE

Starting CNS%	0:00 – 0:30	0:31 – 1:00	1:01 – 1:30	1:31 – 2:00	2:01 – 3:00	3:01 – 4:00	4:01 – 6:00	6:01 – 9:00
10%	10%	8%	6%	5%	4%	3%	2%	1%
20%	20%	16%	13%	10%	8%	5%	3%	1%
30%	30%	24%	19%	15%	12%	8%	5%	2%
40%	40%	32%	25%	20%	16%	10%	6%	2%
50%	50%	40%	32%	25%	20%	13%	8%	3%
55%	55%	44%	35%	28%	22%	14%	9%	3%
60%	60%	48%	38%	30%	24%	15%	10%	4%
65%	65%	52%	41%	33%	26%	16%	10%	4%
70%	70%	56%	44%	35%	28%	18%	11%	4%
75%	75%	60%	47%	38%	30%	19%	12%	5%
80%	80%	64%	50%	40%	32%	20%	13%	5%
85%	85%	68%	54%	43%	34%	21%	14%	5%
90%	90%	72%	57%	45%	36%	23%	14%	5%
95%	95%	76%	60%	48%	38%	24%	15%	6%
100%	100%	80%	63%	50%	40%	25%	16%	6%

TecRec DSAT

Example: After the first dive, your CNS was 68%. After an hour and 40 minutes, you make your second dive, which accumulates 43% "CNS clock" time. What is your CNS percent after the dive?

Answer: 78%. After 1:40 surface interval, 68% (round to 70%) yields 35%. 35% + 43% = 78%.

As with any table, software or computer, stay well within limits and be conservative.

Planning a Decompression Dive: Using a Single Gas Computer

Now let's start putting everything you've been learning together by planning a decompression dive the simplest way possible — by using a single gas computer, with gas switches to pad the dive and make it more conservative. This type of deco plan has six advantages that make it a good method for a lot of dive situations.

1. Maximum conservatism — this technique keeps you well within decompression model limits.
2. Simplicity in implementing — your computer generates required decompression and guides you through the dive.
3. Not based on maximum depth — although you're conservative, decompression is based on actual profile rather than the deepest depth, which can reduce your overall deco time.
4. Gas flexibility — since the computer assumes you're decoing based on your back gas, you can deco on back gas or any other blend with an equal or greater oxygen fraction (within its oxygen limits); this lets you use whatever gases you have available, and makes it easier to handle a deco gas problem (lost, regulator malfunction, etc.) because you can always use your back gas.
5. Easy back up decompression — by using a second single gas computer of same type, or single gas table for the gas in question, you have a simplified back up.
6. Accelerated decompression option — once you learn accelerated decompression techniques, you can generate accelerated decompression tables with desk top deco software based on the gases you'll use — good for emergency get-out-of-the-water-sooner situations (such as a leaking dry suit). Keep in mind that compared to using EANx/oxygen with an air schedule, accelerated deco is a trade: a less conservative decompression for less time decompressing.

The flexibility this technique offers makes it a good method for gaining experience with decompression diving.

If using a single gas enriched air computer, you set it for the bottom EANx, and do the same with your back up computer (if you're using one instead of, or in addition to, tables). If you're using air computers, there's nothing to set.

You need to plan oxygen exposure and gas requirements. For this, you'll use a published dive table or generate one with desk top deco software based on making the entire dive, including deco, using the bottom gas. Calculate oxygen exposure based on actual gases you'll use, and gas requirements based on your SAC rates and the times at depth. Don't forget to compare your actual gas volume with your gas requirements to be sure the gas supply you actually have is enough to cover the dive plan.

Some readily available tables designed for commercial/military divers, such as the US Navy tables, are less conservative than popular dive computers. If using one of these, you may want to use the next deeper depth and time for planning purposes, because that will be closer to your dive computer's schedule.

Example (Metric):
You plan a dive to 44 metres using a single gas enriched air computer set for EANx26. You plan to decompress using EANx80 from 9 metres to the surface. You estimate that your bottom time will be 40 minutes. Your dive tables for EANx26 show that 40 minutes at 44 metres requires 3 minutes decompression at 12 metres, 10 at 9 metres, 17 at 6 metres and 43 at 3 metres. Your ascent rate is 10 mpm. Your SAC rate is 19 litres per minute on the working part of the dive, and 16 lpm when decompressing.

- Following the rule of thirds, how much of each gas do you need for this dive?

  Answer: 6771 litres of EANx26; 2489 litres of EANx80

- If you have twin 18 litre cylinders with 170 bar of EANx26 do you have enough EANx26 for the dive? If you have a 13 litre cylinder with 205 bar of EANx80, do you have enough EANx80 for the dive? How much do you have of each?

  Answer: No and yes.

- What are your OTUs and "CNS clock" after the dive?

  Answer: OTUs=160.8; CNS%=85.1%

- If you'll be diving again in two and a half hours, and you'll be staying within the mission averages for three days of diving, how much "CNS clock" time and how many OTUs can you have on the second dive?

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)
EANx26	4514	6771						
EANx80	1659	2489						

OTU Total 160.8

CNS Total 85.1%

Total Deco 77 min

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
44	40		19	5.5	4180	EANx26	1.43*	1.67	66.8	0.83	33.2
28 (ascent)	3		19	4.0	228	EANx26	1.04	1.07	3.2	0.42	1.3
12	3		16	2.2	106	EANx26	0.57	0.20	0.6	0.14	0.4
9	10		16	1.9	304	EANx80	1.54	1.81	18.1	2.22	22.2
6	17+1		16	1.6	461	EANx80	1.30	1.45	26.1	0.55	9.9
3	43		16	1.3	894	EANx80	1.04	1.07	46.0	0.42	18.1

** Note: Actual PO_2 = 1.4; 1.43 from rounding on table to 45 m.*

Answer: Allowable CNS = 64%; allowable OTUs = 458.5

EANx26 = 4180 + 228 + 106 = 4514 l; 4514 x 1.5 = 6771 litres

EANx80 = 304 + 461 + 894 = 1659 l; 1659 x 1.5 = 2489 liters

18 litres x 170 = 3060 litres, 3060 x 2 (doubles) = 6120 litres EANx26

13 litres x 205 = 2665 litres EANx80

OTUs = 66.8 + 3.2 + 0.6 + 18.1 + 26.1 + 46.0 = 160.8

"CNS clock" = 33.2% + 1.3% + 0.4% + 22.2% + 9.9% + 18.1% = 85.1%

After two and a half hours, CNS 85.1% = 36%; 100% - 36% = 64%

Three day mission allows 1860 OTUs, average 620 per day. 620 - 160.8 = 459.2

Example (Imperial):
You plan a dive to 145 feet using a single gas enriched air computer set for EANx26. You plan to decompress using EANx80 from 30 feet to the surface. You estimate that your bottom time will be 40 minutes. Your dive tables for EANx26 show that 40 minutes at 145 feet requires 3 minutes decompression at 40 feet, 10 at 30 feet, 17 at 20 feet and 43 at 10 feet. Your ascent rate is 30 fpm. Your SAC rate is .8 cubic feet per minute on the working part of the dive, and .65 cf when decompressing.

- Following the rule of thirds, how much of each gas do you need for this dive?

  Answer: 289.7 cubic feet of EANx26; 101 cf of EANx80

If you have twin 104 cf cylinders, working pressure 2400 psi, with 2500 psi of EANx26 do you have enough EANx26 for the dive? If you have a 104 cf cylinder, working pressure 2400, with 2300 psi of EANx80, do you have enough EANx80 for the dive? How much do you have of each?

Answer: No and no. EANx26 = 216 cf; EANx80 = 100 cf (99.8)

- What are your OTUs and "CNS clock" after the dive?

Answer: OTUs=162.8; CNS%=85.5%

- If you'll be diving again in two and a half hours, and you'll be staying within the mission averages for three days of diving, how much "CNS clock" time and how many OTUs can you have on the second dive?

Answer: Allowable CNS = 64%; allowable OTUs = 457.2

DSAT TecRec DIVE PLANNING SLATE

Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)	Gas	Planned Vol	w/Reserve(x1.5)
EANx26	189.9	289.7						
EANx80	67.4	101						

OTU Total 162.8

CNS Total 85.5%

Total Deco 77 min

Depth	Time	Runtime	SAC	Conv. Factor	Volume	Gas	PO_2	OTU / min	OTUs	CNS% / min	CNS percent
145	40		.8	5.5	176.0	EANx26	1.44*	1.69	67.6	0.83	33.2
93 (ascent)	4		.8	4.0	12.8	EANx26	1.05	1.08	4.3	0.42	1.7
40	3		.65	2.2	4.3	EANx26	0.58	0.21	0.6	0.14	0.4
30	10		.65	1.9	12.4	EANx80	1.53	1.82	18.2	2.22	22.2
20	17+1		.65	1.6	18.7	EANx80	1.28	1.45	26.1	0.55	9.9
10	43		.65	1.3	36.3	EANx80	1.04	1.07	46.0	0.42	18.1

**Note: Actual PO_2 = 1.4; 1.45 from rounding on table to 150 ft.*

EANx26 =176 + 12.8 + 4.3 = 193.1 cubic feet; 193.1 x 1.5 = 289.7 cubic feet

EANx80 =12.4 + 18.7 + 36.3 = 67.4 cubic feet; 67.4 x 1.5 =101 cubic feet

2500 ÷ 2400 = 1.04, 1.04 x 104 = 108 cubic feet, 108 x 2 (doubles) = 216 cubic feet EANx26

2300 ÷ 2400 = .96, .96 x 104 = 100 cubic feet (99.8) EANx80

OTUs = 67.6 + 4.3 + 0.6 + 18.2 + 26.1 + 46.0 =162.8

"CNS clock" = 33.2% +1.7% + 0.4% + 22.2% + 9.9% +18.1% = 85.5%

After two and a half hours, CNS 85.5% = 36%; 100%-36% = 64%

Three day mission allows 1860 OTUs, average 620 per day. 620-162.8 = 457.2

That's a lot of number crunching, though it's not particularly difficult. Again, desk top deco software calculates your gas supplies and oxygen exposure, and with most you can enter the actual gases and the entire profile (not an accelerated deco schedule, but with the stops entered as way points based on what you expect the times to be using your single gas computer) to get your oxygen exposure. But, software can't figure out your tank capactities and actual gas supplies. You have to do that.

THREE

Tec Exercise – 3.2

1. According to prevailing theory, the __________ the ___________ of a gas, the more narcotic it is.
2. Oxygen is __________ as soluble as nitrogen.
3. When accounting for narcosis in dive planning, you must consider (check all that apply):
   - ☐ a. individual tolerance
   - ☐ b. environmental conditions
   - ☐ c. task loading
   - ☐ d. your team mates' tolerance
4. The general limit for technical diving using air/enriched air is _________.
5. An air break is a switch to air or your lowest oxygen gas for five minutes every 20 to 25 minutes while decompressing. Its purpose is to reduce the risk of pulmonary oxygen toxicity.
   - ☐ True ☐ False
6. Using the Equivalent Air Depth and Oxygen Management Table, when using EANx29 at 15 metres/50 feet, your OTU per minute rate is _________ OTUs per minute.
7. Using the Equivalent Air Depth and Oxygen Management Table, when using 100 percent oxygen at 5 metres/15 feet, your CNS percent per minute rate is _________ CNS percent per minute.
8. When repetitive diving and diving for several days in a row, with respect to oxygen exposure and choosing the "ideal" gas blend for a dive
   - ☐ a. simply find the gas with its 1.4 PO_2 maximum depth equal to or just deeper than the planned depth.
   - ☐ b. your OTUs and "CNS clock" may require a gas with less oxygen than what would otherwise be considered "ideal."
   - ☐ c. None of the above.
9. Using the CNS Surface Interval Credit Table, if your CNS percent is 73 percent, after two hours, ten minutes at the surface it is _________ percent.
10. The advantages of planning a decompression dive with a single gas computer and EANx/oxygen as a pad to make the schedule more conservative include (check all that apply):
    - ☐ a. simplicity in implementing
    - ☐ b. gas flexibility
    - ☐ c. easy back up decompression
    - ☐ d. shortest possible hang time

Check it out:
1. greater, solubility. 2. twice. 3. a,b,c,d. 4. 50 metres/165 feet. 5. False. Its purpose is to reduce the risk of CNS oxygen toxicity. 6. 0.52. 7. .83%. 8. b. 9. 30. 10. a,b,c. d is not correct — the shortest possible hang time comes from accelerated decompression.

Emergencies III

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What should you do if one of your stage/deco cylinder regulators malfunctions?
2. What should you do if your dive computer fails?
3. What should you do if you lose your dive tables?
4. What should you do if, on a decompression dive, you have no decompression information at all?
5. What should you do if you find narcosis affecting you or your team mates' abilities to accomplish the mission and/or dive safely?
6. What should you do if you discover a team mate has separated from you?

This section on emergencies covers some situations that can happen, but by following the right procedures, you can handle with confidence of a favorable outcome. Others aren't so clear cut — but, they're also among the easiest to prevent if you dive conservatively and skillfully, follow your predive preparation procedures and don't cut any corners.

Stage/Deco Cylinder Regulator Failure

A stage/deco cylinder regulator can malfunction and freeflow due to dirt/debris, or due to valve seat failure, etc. or in cold water, due to freezing. This is one reason why you keep the valve closed until you need the cylinder, especially when you stage a cylinder. You don't want to come back to an empty decompression cylinder! The situation's most critical with a deco cylinder on an accelerated deco dive because you need the gas, and less critical when making a padded deco dive because using back gas takes away your extra conservatism, but you can usually still decompress adequately.

If you have a failure and runaway free flow, close the valve and switch to back gas. If you suspect that dirt/debris in the second stage caused the freeflow, and believe you can clear it up *quickly* by flushing them out, do so. Otherwise, remove the regulator and replace it with one from another stage/deco cylinder or from off your back set. You can do this yourself, though it's usually easier to get a team mate to help. Keep an eye on your stop depth as you do this.

Underwater switches aren't exactly wonderful for either regulator because they'll flood. But it'll get you through the dive — after the dive, have both regulators serviced, with special attention to the SPGs. SPGs are dead ends that can trap water and slowly corrode until they fail.

Note that for this to work, you need to always have at least two regulators that fit every stage/deco cylinder — the one on it and one you can move to it. This means that if you have multiple stage/deco cylinders, both need to be DIN or yoke system. If you have a single stage/deco cylinder, then it needs to be DIN or yoke to match those on your main rig. It's acceptable, though not ideal, to carry a

DIN adapter so you can put a DIN regulator from your back rig on a yoke stage/deco cylinder.

Keep in mind that switching regulators underwater may not be a feasible option in some circumstances. In some areas, regulators for enriched air nitrox have reverse threads from standard regulators, so you may only have the option of using another deco cylinder regulator. In cold water environments, if you regulator freeflows due to freezing, an underwater switch may not help because water in the new regulator may also freeze. Consider these factors when planning your dive. If you have no other options, you may be able to use a free flowing regulator by slightly opening and then closing the deco cylinder valve for each breath. For a frozen regulator, it may work to simply shut down the freeflow and wait for the regulator to warm to the surrounding water temperature.

Dive Computer Failure

If you have not seen a dive computer failure, you have not been diving enough. Well, or you're really fortunate, because like all electronic instruments, it happens. How you handle it if it happens underwater varies, but if you're properly prepared and equipped, it's really an inconvenience, not a major emergency. Your options, in order of preference, are:

1. If still in a no stop situation, abort the dive and surface.
2. Switch to a back up computer for deco information and abort the dive.
3. If no back up computer, decompress based on your back up depth gauge, timer and dive tables (printed from desk top deco software).

In most instances, you abort the dive if your computer fails because you're on your back up system (some people dive with two computers, plus a back up depth gauge, timer and tables so they still have back up with a single failure and may continue the dive).

Lost Dive Tables

If making a tables-based dive (such as an accelerated decompression dive based on desk top deco software), losing your tables is as serious as computer failure — if you're properly prepared and equipped, it's an annoyance. Otherwise, it's trouble. Again, you have several options:

1. If you're still in a no stop situation, end the dive.
2. Switch to your back up tables. (Plus you should have your primary schedule on your slate).

3. If you've lost your back up tables (and slate), switch to your team mate's back up tables (this is one reason you dive with the same gases).
4. If those aren't available, you and your team mate ascend together following your team mate's set.

No Decompression Information At All

Being without deco information on a decompression dive shouldn't happen. If you and your team mates dive with the same gases and carry appropriate back up computers and/or tables/gauges, the chances of it happening are nil. Virtually every incident where it has happened involve a diver who didn't have the required back up. Think about it — to get in this situation, you have to break a bunch of rules or be unbelievably unlucky. You have to not only not have back up, but also be separated from your team.

But if it were to happen end the dive immediately and start up (if you have not already), hopefully before reaching your planned bottom time. Think about your planned dive — you should have some idea of what the required stops were, such as the deepest stop, the length of the last stop, what gases to use at which depths, etc.

Decompress as best you remember, *slightly* padding deeper stops. Heavily pad the last one or two stops. Use up all your remaining decompression gas at the last stop (5 metres/15 feet), especially oxygen if you have it. Write down what you do so you can compare it with the schedule when you get to the surface, and so you can calculate your oxygen exposure.

After surfacing, limit activity for several hours, stay hydrated and monitor yourself for DCS symptoms. However, provided you hadn't exceeded your planned depth and time, and provided you were diving with an appropriate reserve, you should find you have over decompressed rather than under. But dive well, and this should be a situation you never face.

Narcosis

This is a bit repetitive to what you read earlier, but important. Diving below 30 metres/100 feet, most people find narcosis noticeable, but you should still be able to function normally. As you learned earlier, experience with narcosis increases your ability to function with it. Gain greater depth experience gradually, and take your susceptibility, the environment, your team, etc. into account when you plan your dives.

If you find that you're having difficulty concentrating, accomplishing your tasks and so on, assume that narcosis is impairing you and ascend to a shallower depth, or if necessary, end the dive. Do the same if one of your team mates acts the same way.

Be especially alert for signs and symptoms such as looking at your computer or tables and not understanding what they're telling you, the inability to perform simple motor skills (like knot tying) etc. These all alert you that it's time to ascend. Some divers use signals to check each other for narcosis, such as asking each other for gas pressure. Delayed or confused responses suggest that narcosis may be an issue. That's when the prudent step is to give the thumbs up and head home.

If you find that you're having difficulty concentrating, accomplishing your tasks and so on, assume that narcosis is impairing you and ascend to a shallower depth, or if necessary, end the dive. Do the same if one of your team mates acts the same way.

Missing Team Mate

You're swimming along a wreck. Two seconds ago the three of you were together. Look back and . . . where did Leo get to? Missing team mate. Now what?

How you handle this will depend on the dive logistics, and it should be part of the Live step in your dive plan. You can apply some guidelines in establishing what the plan of action will be. The first option is for the remaining team to stay together and search briefly in the immediate area. The second option is to have a designated point to meet, with an agreement to do a brief search, limits allowing, if the team mate doesn't show up after a specified period. Third, if you don't regroup after the brief search or a reasonable wait at the designated point, return to the ascent point. You often regroup there.

In some circumstances a separated team mate may have to ascend separately under a lift bag. Support divers, if present, may notify you when they've made contact. In any event, do not continue the dive with a broken group — this violates the team concept. If after enacting your plans for regrouping you can't reunite, the dive should end.

Tec Exercise – 3.3

1. If your stage/deco cylinder regulator malfunctions you should (check all that apply):
   - ☐ a. close the valve.
   - ☐ b. switch a working regulator to the cylinder in question.
   - ☐ c. clean it out quickly if you believe you can and that that's the problem.
   - ☐ d. None of the above.
2. If your dive computer fails (check all that apply):
   - ☐ a. if in a no stop situation, abort the dive and surface.
   - ☐ b. switch to a back up computer and abort the dive.
   - ☐ c. decompress based on your back up depth gauge, timer and dive tables.
   - ☐ d. None of the above.
3. If you lose your tables on a tables-based dive, (check all that apply):
   - ☐ a. if in a no stop situation, end the dive.
   - ☐ b. ascend immediately without decompressing and breathe oxygen at the surface.
   - ☐ c. use your back up tables.
   - ☐ d. ascend with your team mate follow your team mate's tables.
4. If, on a decompression dive, you have no decompression information at all, you should (check all that apply):
   - ☐ a. immediately end the dive and start up.
   - ☐ b. remember your planned schedule as best you can and decompress accordingly.
   - ☐ c. pad deep stops slightly and use all your remaining deco gases at the last stop.
   - ☐ d. kick yourself in the butt for not having the back ups you should.
5. If you find narcosis affecting you or one of your team mates' abilities to accomplish the mission and/or dive safely, you should (check all that apply):
   - ☐ a. Ascend or abort the dive.
   - ☐ b. Head for shallow water or the surface.
   - ☐ c. Move up in the water column, all the way to the top if necessary.
   - ☐ d. Go deeper.
6. If you discover a team mate separated from the team, your options may include (check all that apply):
   - ☐ a. Keep the remaining team together and search briefly.
   - ☐ b. Meet at a designated point.
   - ☐ c. Follow the plan for regrouping from the Live step in dive planning
   - ☐ d. End the dive if you can't reunite.

Check it out:
1. a,b,c. 2. a,b,c. 3. a,c.d. 4. a,b,c. d is appropriate, but not until after the dive. 5. a,b,c. If you checked d, burn all your certification cards. 6. a,b,c,d.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the guidelines and procedures for when to switch to and from stage/deco cylinders?
2. What are turn around points, and how do you determine them?
3. How do you learn to account for environmental variables, such as current, visibility, temperature and waves when planning a tec dive?
4. What are four guidelines to consider when planning to tec dive in an unfamiliar environment?

Techniques III

When to Make Cylinder Switches

From your practice in Training Dives Two and Three, plus what you've been learning and applying in the Gas Planning discussions, you've probably got a basic grasp on when you make cylinder switches to go from one gas to another. Let's look at this with some more detail.

The guidelines for switching differ somewhat for stage cylinders (used for added bottom time, you recall) and deco cylinders (used for decompression). With stage cylinders, the entire team switches and stages together when any one member reaches the switch pressure. On gas-switch, extended no stop dives, you switch when you ascend above the maximum depth for the gas in the cylinder. In this case, stage and deco cylinder switches are very similar. Note that you should follow the NO TOX procedure with stage cylinder switches as well as with deco cylinder switches.

Your tables and dive plan dictate when you switch to your deco cylinders — usually at the first stop depth that calls for a different gas. However, you may switch once you ascend above the maximum depth for the gas and use it as you ascend to the first stop.

For example, suppose your first stop calls for EANx50 at 15 metres/50 feet. You may switch to EANx50 after you ascend above 21 metres/70 feet (maximum deco depth for 50 percent oxygen) and use it as you ascend to 15 metres/50 feet. When using desk top deco software to plan a dive like this, you can schedule in a one minute stop at the maximum depth to give you time to don the cylinder and make the switch. Or, you can simply don it on the fly and NO TOX switch as you ascend to the first stop. (Again, all gas switches should follow the NO TOX procedure.)

Turn Around Points

Turn around points are points in the dive at which you and your team agree to turn the dive around and head up/back to the exit. You determine turn around points ("turn points" for short) when planning your dives (in fact, you've already been learning to determine them). When you or a team mate reaches any one of them, you turn the dive. Factors to consider when determining turn around points include:

- Completing your decompression within your gas planning, without using your reserve.
- The effects of total exposure time (temperature, fatigue).
- Effects on repetitive dives, if any (OTUs, CNS, deco requirements)

All dives have at least two turn around points: the turn point based on the bottom time, and the turn point based on gas consumed. The SPG reading at which you turn around is called turn pressure. (Depth may be a given, so it isn't necessarily a turn point on all dives.)

You may have other turn points based on your mission, logistics or unknown variables in the profile. This may include turn points based on:

- Distance – you turn when you've traveled an approximate maximum distance from the exit.
- Task completion – when you accomplish your mission, the team may agree to turn immediately to minimize decompression.
- Depth – the team agrees to turn the dive upon reaching a certain depth.
- Depth/time combinations – the time turn around point varies with the maximum depth to accommodate decompression within the planned gas supply. For example, "the planned depth is 36 metres/120 feet, we'll turn at 65 minutes. If we exceed that, we'll use 40 metres/130 feet as the maximum depth and turn at 50 minutes."

When setting turn points, don't neglect the KISS (Keep It Super Simple) principle. Too many turn around points gets complicated. Keep it to only a few that cover the plan requirements.

Calculating Your Back Gas Turn Pressure. Calculating your back gas turn pressure means finding the pressure at which you begin your ascent with enough gas to complete your planned decompression and still have one third of your back gas remaining.

1. Start by determining your total back gas volume requirements (bottom plus decompression), including reserve. Determine what cylinders you'll be using to have this volume and their full pressure.

2. Now determine how much pressure (bar/psi) you 'll use breathing that volume, and subtract that from your starting pressure.
3. For metric, divide the volume you'll use on the bottom by the cylinder capactity, then subtract that from the starting pressure.

Turn pressure = Start pressure - (bottom volume ÷ cylinder capacity)

Example (Metric, based on earlier example.):
Previously, you planned a dive to 44 metres using a single gas enriched air computer set for EANx26. You plan to decompress using EANx80 from 9 metres to the surface, with an estimated bottom time of 40 minutes. Your dive tables for EANx26 showed that 40 minutes at 44 metres requires 3 minutes decompression at 12 metres, 10 at 9 metres, 17 at 6 metres and 43 at 3 metres. Your ascent rate is 10 mpm. Your SAC rate is 19 litres per minute on the working part of the dive, and 16 lpm when decompressing. The gas volume results were:

Depth	Time	SAC	C.Fac	Vol	Gas
44 m	40	19	5.5	4180	EANx26
28 m(a)	3	19	4.0	228	EANx26
12 m	3	16	2.2	106	EANx26
9 m	10	16	1.9	304	EANx80
6 m	17+1	16	1.6	435	EANx80
3 m	43	16	1.3	894	EANx80

Following the rule of thirds, you determined you need 6771 litres of EANx26. To meet this requirement, you will dive in twin 21 litre cylinders filled to 162 bar. This gives you 6804 litres of gas (21 x 2 x 162 = 6804). By what pressure should you be starting your ascent so that you will have a one third reserve after completing your decompression?

Answer: 62.5 bar

4180 ÷ 42 (twin 21 litre cylinders) = 99.5; 162-99.5 = 62.5 bar.

THREE

For imperial system, the baseline method is the easiest way to find your turn pressure. Divide the bottom volume by the baseline, and subtract that from the starting pressure.

Turn pressure = starting pressure -(bottom volume ÷ baseline)

Example (Imperial, based on the earlier example.):
Previously, you planned a dive to 145 feet using a single gas enriched air computer set for EANx26. You planned to decompress using EANx80 from 30 feet to the surface. You estimated that your bottom time will be 40 minutes. Your dive tables for EANx26 show that 40 minutes at 145 feet requires 3 minutes decompression at 40 feet, 10 at 30 feet, 17 at 20 feet and 43 at 10 feet. Your ascent rate is 30 fpm. Your SAC rate is .8 cubic feet per minute on the working part of the dive, and .65 cf when decompressing. The gas volume results were:

Depth	Time	SAC	C.Fac	Vol	Gas
145 ft	40	.8	5.5	176.0	EANx26
93 ft(a)	3	.8	4.0	9.6	EANx26
40 ft	3	.65	2.2	4.3	EANx26
30 ft	10	.65	1.9	12.4	EANx80
20 ft	17+1	.65	1.6	17.7	EANx80
10 ft	43	.65	1.3	36.3	EANx80

Following the rule of thirds, you determined you need 285 cf of EANx26. To meet this requirement, you will dive with twin 140 cubic foot 2400 working pressure plus-rated (10% overfill) cylinders filled to 2640 psi. This gives you 308 cubic feet of gas (140 x 2 = 280, 280 + 28 (10% overfill) = 308). By what pressure should you be starting your ascent so you will have a one third reserve after completing your decompression?

Answer: 1136 psi

Baseline = .117 (280 ÷ 2400 = .117)

176 ÷ .117 = 1504; 2640 - 1504 = 1136

Most desktop deco software does not calculate turn pressure because it doesn't know what size cylinders you're using. Therefore, you need to calculate it yourself (but desktop deco software, of course, will calculate the volume requirements, making it a simple process). Notice that when you determine your turn pressure this way, any gas you have in your back cylinders beyond the planned required volume gets added to your reserve.

All dives have at least two turn around points: the turn point based on the bottom time, and the turn point based on gas consumed.

Half Plus 15 bar/200 psi Rule.
As a "shortcut" many divers use the "half + 15 bar/200 psi" rule — take half your doubles pressure and add 15 bar/200 psi. You should be ascending by then. This generally works well (actually conservatively, if you compare to previous examples) when most of your decompression will be made with deco cylinders. If you will use back gas for more than the first one or two stops, calculate as shown to be sure you'll be started up with ample gas for decompression plus reserve.

THREE

Environmental Variables

Tec diving is like recreational diving in that the procedures and techniques vary with the environment. Many of the techniques and procedures you learn in this course will be area specific, just as they were where and when you became an Open Water Diver. When tec diving in a new area, as in recreational diving, you want an orientation to the new area and to any special procedures and techniques that apply to it. Get this orientation from an experienced local tec diver, ideally, a technical diving instructor.

There are four guidelines you can follow to help minimize difficulties you might run into when tech diving in a new environment.

1. Gain experience with a new environment before making challenging tec dives in it. Make recreational and/or no stop dives initially.

2. Master new, area specific equipment and procedures in controlled conditions before applying them on more challenging tec dives.

3. Consult local tec divers. Local methodologies evolve based on local needs; just because something works well in one environment doesn't mean that it's suited to another.

4. Recognize the difference between *local* methods and *inappropriate* methods. In the DSAT Tec Deep Diver course, you learn principles that apply universally to managing your risk in the tec environment. The application methods may vary, but the principles remain.

Disregarding tec diving principles is *not* a "local method." That is, suppose divers in an area commonly dive to 60 metres/200 feet using standard recreational single cylinders and regulators. This does not constitute a local tec diving method because it ignores having an independent regulator in a technical environment — a basic survival principle in the technical envelope. It's *not even* tec diving. It's Russian roulette.

Tec Exercise – 3.4

1. Guidelines and procedures for when to switch to and from stage/deco cylinders include (check all that apply):
   - ☐ a. With stage cylinders, the entire team switches and stages together.
   - ☐ b. Your tables and dive plan dictate switches to deco cylinders.
   - ☐ c. All deco cylinder switches are NO TOX switches.
   - ☐ d. Stage cylinder switches are usually not NO TOX switches.
2. A turn point is a time, SPG pressure or other point at which you and the team have the option of ending the dive.
   ☐ True ☐ False.
3. The best way to learn to account for environmental variables, such as current, visibility, etc., in planning tec dives is to get an ________________ from a local tec diver or tec instructor.
4. Guidelines to consider when planning to tec dive in an unfamiliar area include (check all that apply):
   - ☐ a. Gain experience making recreational and/or no stop dives initially.
   - ☐ b. Master new, area specific equipment and procedures in controlled conditions.
   - ☐ c. Consult local tec divers.
   - ☐ d. Recognize the difference between local methods and inappropriate methods.

Check it out:
1 a,b,c. d is incorrect because all gas or cylinder switches should be NO TOX switches. 2. False. At a turn point you end the dive; no option. 3. orientation. 4. a,b,c,d.

Tec Objectives

By the end of this section, you should be able to:

1. Demonstrate and recognize the hand signals for:
   - line
   - entanglement
   - reel
   - I think I'm bent.
   - question
   - Turn the dive.
2. Identify where your team mates rank in your chain of back up systems.

You should also highlight or underline the answers to these questions as you find them:

3. What is the one back up your team mates provide that you cannot provide yourself?
4. What are the duties of a safety/support diver?

Team Diving III

More Hand Signals

Here are some more signals unique to tec diving. You've probably already learned some or all of these from your instructor during your training dives, but let's go over them anyway so the underwater photographer doesn't feel like he took all these pictures for nothing.

Use the *line* signal for anything pertaining to a line. You might use this to ask where a line is, or to signal a team mate that you've spotted a line.

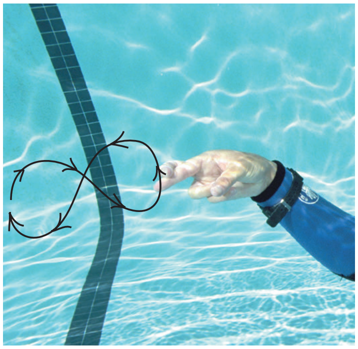
The *entanglement* signal is the same signal as line, but waved in an eight-shape. Try to avoid needing this one too much.

The reel signal is for anything about a reel or reels, and the *I think I'm bent* signal obviously means you suspect you have DCS. Knowing how to signal that you may be bent is important because it allows your support divers and/or team mates to prepare to handle the emergency at the surface even before you get there.

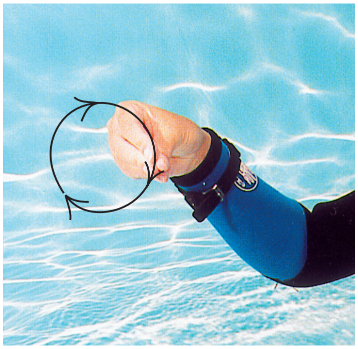
To be clear that you're asking something, start with the *question* signal. You might signal, question - reel, to ask "Do you have the reel?"

Since thumbs up is a command signal that means end the dive immediately, tec divers have a second signal, *turn the dive*. The turn the dive signal means, "Okay, it's time to go, but no emergency or

Line.



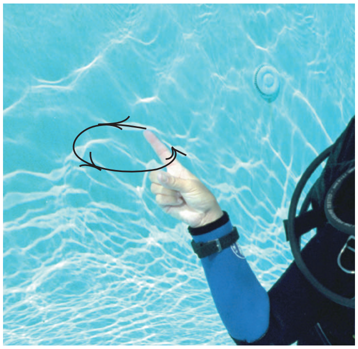
Entangled.



Reel.

I think I'm bent.

Question



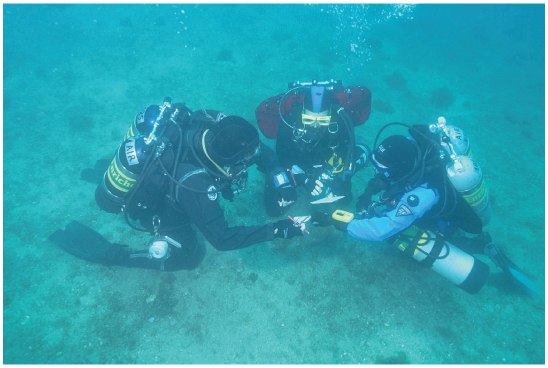
Turn the dive.

hurry." You might use this signal when you hit a turn point. Or, before you hit one, if you're feeling a bit cold and your team mates look a bit bluish, you might signal, question - turn the dive, to ask "Hey, no emergency, but maybe we should we turn the dive?"

Your Team Mates as Back Up Systems

In recreational diving, your team mate is your primary back up system — your first option in the back up chain for most emergencies. This is entirely appropriate within the recreational envelope because in an emergency, all you have to do is get to the surface. In tec diving, your team mate is *not* your primary back up system.

In tec diving, you rely on yourself *first* and you should have back ups for practically everything. Therefore, your team mate is second, third or even further into your back up chain, providing a back up only if your self reliant back ups fail.



Team mates signal each other if they notice anything out of sorts. They remind each other to check gas supplies, time, depth, and so on. Team mates never assume that another is either right or wrong. If they disagree about what's happening or what to do, they resolve the confusion or end the dive if they can't.

The single exception is that your team mates provide your "back up brain," which is the only back up you can't provide yourself. This means you and your team mates dive paying attention to limits, the plan and what's going on. You dive as though you might have to finish the dive alone; no one follows everyone else blindly.

Team mates signal each other if they notice anything out of sorts. They remind each other to check gas supplies, time, depth, and so on. Team mates never assume that another is either right or wrong. If they disagree about what's happening or what to do, they resolve the confusion or end the dive if they can't.

That 's teamwork.

Duties of the Safety/Support Diver

Part of team diving often involves handling support tasks and safety. This is especially true when you're less experienced and working on a large project. Although taking your turn assisting with safety and support may not seem glamorous, it's a great way to gain experience and learn amid substantially more experienced divers.

A safety/support diver generally stays within the no stop limits and attends to divers decompressing. Duties may include, but are not limited to:

1. Checking on divers, assuring they have ample gas, etc.
2. Shuttling gear — exhausted stage/deco cylinders, unneeded equipment up; extra gas, weights down, etc.
3. Watching for and locating divers separated from their teams. Notifying teams that missing divers are located.
4. "Baby-sitting" — hovering near decoing divers to be ready to assist.
5. Sitting standby on the boat or shore, fully geared up and ready to go in to assist in an emergency.
6. Coordinating the boat crew with the needs of the decoing divers.
7. Shuttling communications between the divers and surface support.

THREE

Tec Exercise – 3.5

1. This signal means ___________. [3-28, "Reel" signal inserted here.]
2. In your chain of back up systems, your team mates rank ______ or _______, or even further in.
3. The one back up your team mates provide that you cannot provide yourself is a back up __________.
4. The duties of a safety/support diver include (check all that apply):
   - ☐ a. Check on divers.
   - ☐ b. Shuttling gear.
   - ☐ c. "Baby-sitting."
   - ☐ d. Standby on the boat or shore.

Check it out:
1. reel. 2. second, third. 3. brain. 4. a,b,c,d.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What assumption do technical divers make when they plan a dive?
2. What is a "trust me" dive and why do technical divers avoid them?
3. What do technical divers do with superfluous equipment in an emergency?
4. How do you "think backwards" to assist with planning for possible emergencies?
5. What are six principles for surviving a tec dive?

Thinking Like a Tec Diver III

Self Sufficiency

By now "self sufficiency" should be well hammered into you. Your team mate only backs you up after all your back ups fail. Tec divers plan their dives assuming that they may have to complete a dive alone, separated from the rest of the team. When you make this assumption, you necessarily plan a self sufficient dive.

Self sufficiency helps you manage risk because you're better prepared to handle problems unaided if necessary. You've had to think about problems ahead of time, and you, and your team, have *multiple* resources to apply to manage a single problem.

But, though you're self sufficient, you and your team work together, maintaining your "back up brains" for each other. And, while you should be able to handle problems by yourself, when the time comes, you and your team mates help each other as much as possible.

"Trust Me" Dives

A "*trust me*" dive is a dive in which one diver relies on another to complete the dive safely. Tec divers avoid them because on a "trust me" dive, you dive using your "back up brain" only — your brain isn't up to the dive. On a "trust me" dive, separation from the leading diver may make it impossible to complete the dive safely.

Following a more experienced diver is not a "trust me" dive *if* you can, at any point in the dive, abort and complete it without assistance. In this case, you're gaining experience and extending your limits by learning from a more seasoned diver — quite another situation.

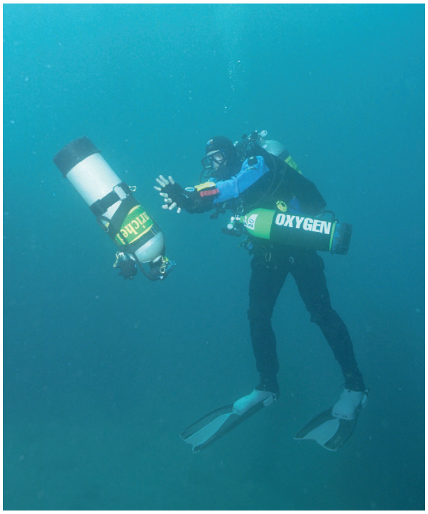
You should ask yourself whether you would be capable of finishing a planned dive entirely on your own from any point in a dive, or in an emergency, be reasonably able to assist a team mate from any point in the dive. If you can't say "yes," then you're not ready for the dive.

"Trust me" dives usually result when divers attempt dives well beyond their experience and training. If you ever find yourself considering one, stop and remember that you're probably going beyond what you're ready to take on. Remember, any diver can abort the dive at any time. That includes aborting a "trust me" dive before it begins.

Equipment is Disposable

As a tec diver, you'll invest a lot in your gear and in maintaining it. Some individual items, such as multigas computers, cost a lot. But, you have to have the mindset that it's all disposable in an emergency. In the extreme, anything that's superfluous to handling an emergency and completing a dive safely is disposable and gets ditched immediately. An empty stage bottle that's hindering an ascent to safety is a liability. Throw it away.

Similarly, you can't get attached to your gear. If something can't do the job right, you replace it, no matter how new, how expensive or how many years of great service it's given you.



In the extreme, anything that's superfluous to handling an emergency and completing a dive safely is disposable and gets ditched immediately. An empty stage bottle that's hindering an ascent to safety is a liability. Throw it away.

Thinking Backwards

Dive planning and emergency preparation is a mental process based on anticipating the mission needs and preparing for realistic problem scenarios. A good strategy for emergency planning is to include *thinking* backwards in your dive planning.

Imagine you're at the furthest point in your dive. Imagine realistic problems that might stand between you and returning safely to the surface. For each one, think about what you need to survive the dive independently, then make sure you have those resources.

It's a simple, yet effective process, but a few cautions. First, don't create a problem by carrying gear or following a procedure in trying to solve an *unrealistic* problem. Let your imagination run away with you and eventually you'll stop diving as you think up scenarios you can't solve. You can fantasize equally unsolvable horrors about walking down the street, but (hopefully) you don't really let these thoughts keep you from sauntering down to the corner market.

Second, work one problem at a time as you go through the dive mentally, and beware of "paralysis through analysis." Think things through and then move on. Over analyzing is no more useful than under analyzing.

Principles for Surviving a Tec Dive

You may have noticed that this course focuses on being alive and unhurt after a tec dive. (A Good Diver's Main Objective Is To Live). Therefore, the six principles for surviving a tec dive should be nothing new to you. Think of these as survival principles you never violate, though there may be different ways to follow them, depending upon the environment.

The Principle of Secondary Life Support. You should have at least two independent usable regulators, at least *two* independent sources of time, depth and decompression information, and at least two methods for controlling buoyancy. You should have at least two of anything that keeps you alive. If any one fails, you abort the dive on the other.

The Principle of Gas Reserve. You should have ample gas to handle reasonably possible emergencies and still complete your decompression (usually thirds). During an emergency, *time* is what you need to solve the problem — your reserve gives you that time.

The Principle of Self Sufficiency. At *any* point in a dive, you should be able to complete it independently.

The Principle of Depth. Your dive plan should account for narcosis, decompression, oxygen toxicity and gas supply needs based on a planned depth and/or a maximum contingency depth (and times) that you do not exceed.

The Principle of Simplicity (KISS principle). Your dive should be planned as simple as possible, with complexities eliminated.

The Principle of Procedure and Discipline. You follow the rules and work the procedures *without exception* on every dive, no matter how familiar the dive and no matter how much experience you have. To state this in a negative context: Cutting corners kills.

Tec Exercise – 3.6

1. Tec divers plan their dives assuming they'll have to finish the dive ____________.
2. A "trust me" dive is a dive in which one diver ______on another to complete the dive safely.
3. Anything that's superfluous to handling an emergency and completing a dive safely is ___________.
4. To apply "thinking backwards" to assist with planning for possible emergencies, you (check all that apply):
   - ☐ a. Imagine realistic problems — that might stand between you and returning safely to the surface.
   - ☐ b. For each, think about what you need to survive the dive.
   - ☐ c. Be sure you or a team mate has what it takes to solve each problem.
   - ☐ d. Avoid trying to solve unrealistic problems.
6. The six principles for surviving a tec dive are:
   1. The Principle of ______________________________ ______________
   2. The Principle of ______________________________ ______________
   3. The Principle of ______________________________ ______________
   4. The Principle of ______________________________ ______________
   5. The Principle of ______________________________ ______________
   6. The Principle of ______________________________ ______________

Check it out:
1. alone. 2. relies. 3. disposable. 4. a,b,d. c is incorrect because you should be able to solve problems independently. 5. Secondary Life Support, Gas Reserve, Self Sufficiency, Depth, Simplicity, Procedure and Discipline.

THREE

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan Training Dives Four and Five by appropriately and accurately accounting for logistics, gas requirements for each diver, OTUs, CNS% and maximum depth based on personal SAC rates, dive profiles, gas blends to be used, environmental details and other information provided by the instructor as necessary about the dives.
2. Working as a team, think backwards through either dive (as assigned by the instructor) from the furthest point imagining realistic problems that might stand between you and surfacing, and formulate realistic solutions for each, drafting a paper with your list of problems and solutions.

Preview: Practical Application Three

During this practical application, you'll work in teams to plan Training Dives Four and Five based on information your instructor provides. Consider A Good Diver's Main Objective Is To Live and refer back to this manual as you plan. Your instructor will provide the basis for determining your deco schedule and have you calculate, OTUs and CNS for each diver and gas, plus gas requirements including one-third reserve, tank base lines, turn points, equipment requirements, logistics, emergency procedures and other information from the A Good Diver's Main Objective Is To Live planning process. You will perform all calculations by hand, though you may compare your results to desk top deco software.

Although these will be no stop dives, you will plan the dives as simulated decompression dives. Your plans should contain all information you would need to make the dives.

Your instructor will also have you put the "thinking backwards" principles into practice by having you and your team mates walk through one of the dives from the furthest point, considering reasonable possible problems and how you would provide solutions to them. Your instructor will have you write these down to discuss.

Preview: Training Dive Four

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure.
2. Independently don a single deco cylinder at the surface.
3. Descend along a line to the bottom, maintaining control of depth and descent speed by adjusting buoyancy.
4. Working in a team, perform appropriate bubble checks and descent checks.
5. Swim for at least two minutes and a distance of at least 18 metres/60 feet sharing air with the long hose as both the donor and receiver.
6. Independently stage a deco cylinder following the procedures for correct staging described previously in this course.
7. Independently retrieve and don the previously staged deco cylinder.
8. Perform a SAC swim by swimming for approximately 10 minutes at a level depth, recording the required information for subsequent calculation.
9. Deploy a lift bag from the bottom.
10. Perform the gas shut down drill within 60 seconds (40 seconds if no isolator valve).
11. While in midwater ascending along a line, switch to the decompression cylinder while following the NO TOX procedure.
12. On a line in midwater, simulate two decompression stops, one at 6 metres/20 feet for five minutes and the next at 5 metres/15 feet for 12 minutes, breathing from the deco cylinder, and recording required information for subsequent decompression SAC calculations.
13. Independently remove the decompression cylinder at the surface.
14. Demonstrate time/depth/gas supply awareness by writing on a slate the depth and time at the point the diver consumes each 35 bar/500 psi of back gas.

Predive briefing and gearing up

Training Dive Four

- Note the time and depth at the point you reach each 35 bar/500 psi consumed.

  Entry — appropriate for environment

  Weight check (if needed)

  Bubble check

  Don deco cylinder at surface

  Descent

  Descent check

  Remove deco cylinder and stage it on bottom.

  Long hose drill

  Retrieve cylinder

  SAC swim — return to ascent line

  Deploy lift bag from bottom

  Gas shut down drill

  Free time in general area for experience and practice

  Ascend line — NO TOX switch to deco bottle

  SAC deco

  Surface — remove deco cylinder at surface

  Recheck weight (if necessary)

  Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Preview: Training Dive Five

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Independently don two deco cylinders at the surface.
3. Descend along a line to the bottom, maintaining control of depth and descent speed by adjusting buoyancy.
4. Remove and stage two deco cylinders on the bottom following the previously described procedures.
5. Swim 10 metres/30 feet sharing gas with the long hose as a donor with a mask, and as a receiver without a mask.
6. Retrieve and don two deco cylinders following the previously described procedures.
7. Swim for approximately three minutes at an accelerated pace, as though fighting a mild current, recording the required information for subsequently calculating SAC rates for higher-than-normal exertion.
8. Complete the gas shutdown drill within 45 seconds.
9. Deploy a lift bag from the bottom as a team, and ascend six metres/20 feet along the lift bag's line.
10. Switch to the appropriate deco cylinder following the NO TOX procedure and use it to make a simulated three minute decompression stop at 9 metres/30 feet and six minutes at 6 metres/20 feet, while recording required information for subsequent decompression SAC calculations.
11. From a simulated decompression stop at 6 metres/20 feet using a decompression cylinder, ascend to 5 metres/15 feet and switch to another decompression cylinder following the NO TOX procedure, and make a simulated deco stop for 14 minutes, recording required information for subsequent decompression SAC calculations.
12. Independently remove two decompression cylinders at the surface.
13. Demonstrate time/depth/gas supply awareness by recording on a slate the depth and SPG reading at each 12 minutes throughout the dive.

Predive briefing and gearing up

Training Dive Five

- Record depth and SPG reading at each 12 minute interval throughout the dive.

Entry — appropriate for environment

Weight check (if needed)

Bubble check

Don deco cylinders at surface

Descent

Descent check

Remove deco cylinders and stage them on bottom.

No mask long hose drill

Retrieve cylinders

SAC faster swim — return to ascent line

Gas shutdown drill

Free time in general area for experience and practice

Deploy lift bag from bottom

Ascend lift line bag 6 metres/20 feet line

Ascend main line — NO TOX switch to first deco bottle

SAC deco

Ascent to 5 metres/15 feet, NO TOX switch to second deco bottle — 14 minute stop with SAC deco and air break practice

Surface — remove deco cylinders at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Calculate individual SAC rates

Log dive for instructor signature.

KNOWLEDGE Review – Chapter Three

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. List three reasons why tec divers consider a slate standard equipment.

   1.____

   2.____

   3.____

2. List the depth limits that arise from narcosis concerns and explain how to account for narcosis in dive planning.

3. How do you perform an air break? Why should you do them?

4. What are six advantages of decompressing based on a single gas computer or table and using enriched air and/or oxygen for conservatism?

   1.____

   2.____

   3.____

   4.____

   5.____

   6.____

5. (Metric) You plan a dive to 50 metres using a single gas enriched air computer set for air. You plan to decompress using oxygen from 6 metres to the surface. You estimate that your bottom time will be 25 minutes. Using desk top deco software, you generate air dive tables that show that 25 minutes at 50 metres requires 2 minutes decompression at 9 metres, 4 at 6 metres and 13 at 3 metres. Your ascent rate is 10 mpm. Your SAC rate is 22 litres per minute on the working part of the dive, and 18 lpm when decompressing.

   - Following the rule of thirds, how much of each gas do you need for this dive?
   - If you have twin 21 litre cylinders with 150 bar of air, how much gas volume do you have? Is it enough for the dive? At what back gas pressure should you leave the bottom to assure you can complete your decompression and have a one-third reserve left? If you have a 7 litre cylinder with 195 bar of oxygen, how much gas volume do you have? Is it enough for the dive?
   - What are your OTUs and "CNS clock" after the dive?
   - If you'll be diving again in three hours, and you'll be staying within the mission averages for five days of diving, how much "CNS clock" time and how many OTUs can you have on the second dive?

Depth	Time	SAC	C.Fac	Vol	Gas	PO_2	OTU/min	OTUs	CNS%/min	CNS%

5. (Imperial) You plan a dive to 165 feet using a single gas enriched air computer set for air. You plan to decompress using oxygen from 20 feet to the surface. You estimate that your bottom time will be 25 minutes. Using desk top deco software, you generate air dive tables that show that 25 minutes at 165 feet requires 2 minutes decompression at 30 feet, 4 at 20 feet and 13 at 10 feet. Your ascent rate is 30 fpm. Your SAC rate is .78 cubic feet per minute on the working part of the dive, and .64 cfm when decompressing.

   - Following the rule of thirds, how much of each gas do you need for this dive?

- If you have twin 120 cubic foot cylinders, working pressure 2400 psi, with 2200 psi of air, how much gas volume do you have? Is it enough for the dive? At what back gas pressure should you leave the bottom to assure you can complete your decompression and have a one-third reserve left? If you have a 50 cf cylinder, working pressure 3000 psi, with 2870 psi of oxygen, how much gas volume do you have? Is it enough for the dive?

- What are your OTUs and "CNS clock" after the dive?

- If you'll be diving again in three hours, and you'll be staying within the mission averages for five days of diving, how much "CNS clock" time and how many OTUs can you have on the second dive?

Depth	Time	SAC	C.Fac	Vol	Gas	PO_2	OTU/min	OTUs	CNS%/min	CNS%

6. Explain what to do if your stage/deco cylinder regulator malfunctions.

7. Explain what to do if your dive computer fails.

8. Explain what to do if you lose your dive tables.

THREE

9. Explain what to do if on a decompression dive you have no decompression information at all. What can you do to assure you're not likely to ever be in this situation?

10. What should you do if you find narcosis affecting you or your team mates' abilities to accomplish the mission and/or dive safely?

11. What should you do if you discover a team mate has separated from you?

12. Explain the procedures for when to switch to and from stage/deco cylinders.

13. What are turn around points? How do you determine them?

14. How do you learn to account for environmental variables, such as current, visibility, temperature and waves when planning a tec dive?

15. What are four guidelines to consider when planning to tec dive in an unfamiliar environment?

1.____

2.____

3.____

4.____

16. Explain where your team mates rank in your chain of back ups. What is the one back up your team mates provide that you cannot provide yourself?

17. What assumption do technical divers make when they plan a dive?

18. List the six principles for surviving a tec dive.

1.____

2.____

3.____

4.____

5.____

6.____

Student Diver statement: I've reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date __________

Knowing ignorance is strength.

Ignoring knowledge is sickness.

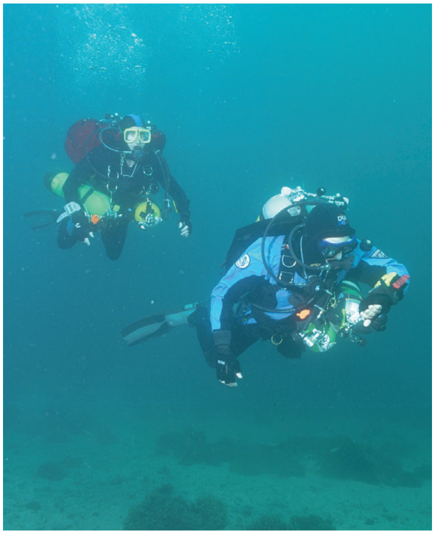
— **Lao Tsu**, Chinese philospher,
6th Century BC, *Tao Te Ching*,
Feng-English translation

Chapter FOUR: The Details

Three behind you and here you are: Chapter Four. By now you should understand the foundational principles behind tec diving well, have a good picture of how they fit together with the techniques and skills tec diving requires, and be growing comfortable with your ability to demonstrate and apply those techniques and skills. As you continue to practice and develop your abilities, Chapter Four starts focusing you on some of the finer points that you need to tec dive successfully. Until you had the big picture behind you, you'd have trouble grasping some of these, or understanding how they fit amid the foundation, framework and structure of what you've learned already.

Chapter Four starts out by looking at still more tec *diving equipment*, but with an interesting spin — homemade gear. You might find it interesting to learn that there's some stuff you're expected to make yourself. From there you'll get back into *gas planning*, which by now you realize forms the very heart of deep tec diving. In this chapter, you'll turn your focus away from decompression diving for a bit, and look at the other option open to tec divers, the gas-switch, extended no-stop dive.

FOUR



At this point, each chapter will become noticeably shorter, but you'll find each Practical Application and Training Dive becoming a bit more demanding as your instructor leaves you and your team to do more and more independently.

Next comes some more about *emergencies* (yep, there's more), and then back to the philosophy lessons and *thinking like a tec diver*. If you're completing only the Apprentice Tec Diver at this point, there'll be some advice just for you, and that'll be it for Chapter Four.

At this point, each chapter will become noticeably shorter, but you'll find each Practical Application and Training Dive becoming a bit more demanding as your instructor leaves you and your team to do more and more independently. That's as it should be — you had to learn a lot of theory and principles to get going, but as you get that behind you, you're zeroing in more and more on *applying* what you've learned.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. Why would technical divers use "homemade" equipment?
2. What are examples of acceptable and unacceptable instances in which a tec diver might use "homemade" gear?
3. What are six general guidelines regarding the use of "homemade" equipment?
4. What is probably the most common "homemade" item used by tec divers?

Equipment IV

Homemade Gear? Because tec diving is evolving rapidly and taking on new challenges, it's not unusual for tec divers to have to *create* special equipment for special purposes, or adapt something for an underwater need. In other words, you might use homemade gear because you have no choice — a commercial version doesn't exist. This really isn't anything new; since diving's early days many new concepts and innovations have originated with improvised inventions.

But of course, you can take things too far. Unless you happen to be talented with metal machining and in gas fluid dynamics, you probably shouldn't be using a homemade regulator! It's considered acceptable to use homemade stuff for equipment that is not critical for safety and/or life support, and for which there exists no professionally made version.

More than you might imagine falls into this category. Examples include specialized compass slates for mapping, bungees-clip arrangements for securing accessories, binder rings for attaching laminated deco tables to slates, and so on. Some accessories designed and appropriate for recreational diving may approximate, but not really meet tec diving's requirements. And, what you have to make at this writing may well be commercially available by the time you read this — progress marches on.

A bungee or surgical tubing "necklace" to hold your short hose second stage is an example of appropriate homemade gear.

Unacceptable examples might (obviously) include a BCD or regulator, line reel, lift bag, etc. These are readily available from professional sources, and they're life support or key safety equipment. An individual who's highly skilled and trained at working with materials might make a suitable version of some of these, but the appropriate degree of skill required would be such that you might consider this a one-of-a-kind professional item anyway.

The following six guidelines apply to "homemade" items:

1. Be sure you *really* need it. Keep things simple.
2. Confirm that a professionally made version does not exist.
3. It should provide a clear benefit or meet an important need, yet not create a hazard nor be essential to safety and life support.
4. Try the item during some no stop, simple dives before using it on a demanding tec dive.
5. Get an opinion from one or more experienced tec divers who you respect.
6. When in doubt, do without it.

Another example of homemade gear is a custom dive table generated by desk top deco software and then laminated or printed on waterproof paper for use or backing up a computer during the dive.

The most common "homemade" item is one you'll make yourself — in fact, you may have already as part of this course: a custom dive table generated by desk top deco software and then laminated or printed on waterproof paper for use during the dive. (The numbers aren't "homemade" of course, but the printing and laminating are.)

Tec Exercise – 4.1

1. You might use homemade equipment because:
   - ☐ a. the equipment you need doesn't exist.
   - ☐ b. the guy at the dive store said you can make a better lift bag yourself.
   - ☐ c. it's the best way to get dependable life support equipment.
   - ☐ d. None of the above.
2. Acceptable examples of homemade gear include (check all that apply):
   - ☐ a. binder rings for slates and tables.
   - ☐ b. regulators.
   - ☐ c. bungees-clip arrangements.
   - ☐ d. BCDs.
3. Unacceptable examples of homemade gear include (check all that apply):
   - ☐ a. binder rings for slates and tables.
   - ☐ b. regulators.
   - ☐ c. bungees-clip arrangements.
   - ☐ d. BCDs.
4. Guidelines regarding the use of homemade equipment include (check all that apply):
   - ☐ a. Be sure you really need it.
   - ☐ b. Try it on simple dives first.
   - ☐ c. Get an opinion from experienced tec divers you respect.
   - ☐ d. If in doubt, try it out.
5. The most common "homemade" equipment is a laminated custom _________ _________.

Check it out.
1. a. 2. a, c. 3. b,d. 4. a,b,c. d is wrong — if in doubt, do without. 5. dive table.

Gas Planning IV

Gas-switch, Extended No Stop Dives

Technical deep diving tends to focus on decompression diving because typically, the depths and times required call for stage decompression. However, when you're trained to handle stage/deco cylinders and make gas switches, you can also make gas-switch, extended no stop dives. As you recall, a gas-switch, extended no stop dive is a dive in which you gain bottom time by ascending to a shallower level and switching to a richer EANx. This gives a longer no stop time through both the multilevel profile and the gas switch. It's no stop diving, but considered tec diving because of the equipment involved, and because you may be carrying gas blends deeper than you can safely breathe them.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are the procedures for staging and switching gases when making gas-switch, extended no-stop dives?
2. What do you do if you cannot switch to your shallower gas blend, or if you must switch back to the deeper blend when making a gas-switch, extended no-stop dive?
3. How do you plan and make a gas-switch, extended no-stop dive using desk top decompression software?
4. How do you plan and make a gas-switch, extended no-stop dive using a multigas dive computer?
5. How can you make a gas-switch, extended no-stop dive more conservative?
6. How do you make a safety stop while within a decompression stop?
7. What is "runtime," how do you determine it, and how do you use it?
8. What do you do if you find yourself slightly ahead of your runtime?
9. What is "gas matching"?

In the last chapter you saw that the no stop increase is substantial, usually with so much time that even using multiple cylinders, you can stay well within no stop limits. Especially when diving shallower than 40 metres/130 feet for the first level, gas-switch extended no stop dives work well with single cylinders for back gas. It is possible, though not common, to make gas-switch, extended no stop dives with more than two blends.

Gas-switch, Extended No Stop Procedure. Gas-switch, extended no stop dives require desk top deco software, and/or a multigas computer. You begin by choosing your back gas based on the bottom depth, and your second blend based on your planned second depth level, making sure you don't exceed the 1.4 ata maximum depth for the blend.

You start the dive at the deepest point, and then at a certain point (usually based on your dive time and/or back gas pressure), you ascend to your second level and NO TOX switch to your stage cylinder with the richer blend. You use the stage cylinder and stay at or above the second level depth for the rest of the dive.

As you recall, it's best to stage a cylinder rather than carry it deeper than you can breathe it safely, and that's quite often possible when making gas-switch, extended no stop dives. But, you may need to carry it the whole time, depending on the site and logistics.

Plan an appropriate reserve in both cylinders, but since you're staying in no stop limits, a 35-70 bar/500-1000 psi reserve is usually adequate. If, for some reason you can't make your gas switch (such as you staged the cylinder and can't retrieve it), you end your dive following the no stop limits/oxygen limits, etc. for your back gas.

If, for some reason, you have a problem with your shallow blend, you obviously have to switch to your back (deeper) gas. If you're not using a multigas computer, it may be simplest to finish the dive as though you made all of it on your back gas. If you've already passed the no stop limits for your back gas when you switch back to it, and if you've been staying within no stop limits (as you should have been), ascend *immediately* and make a three minute or longer safety stop at 5 metres/15 feet.

Planning Gas-Switch, Extended No Stop Dives Using Desk Top Deco Software. Writing a table for a gas-switch, extended no stop dive is pretty straightforward with most desk top decompression programs. Open a new dive profile and enter your first depth, EANx and desired time within no stop limits. Enter your second level, second EANx and find your no stop limit (you may be limited by oxygen instead of no stop time). Some programs won't automatically find no stop limits, so to find them you increase your bottom time until the program says you need decompression, and then back off.

Even if you have a multigas computer, you'll probably find you want desk top deco software for planning gas-switch, extended no stop dives.

When in doubt, assume and plan for a deeper second level as opposed to a shallower one. You can always stay shallower than the planned second level without affecting your dive plan.

Once you have your dive plan down, most programs will generate tables based on variations of your depth and time. Take this with you so you've got flexibility and back up schedules when you execute your dive. It's also wise to carry tables and/or a dive computer based on making the dive entirely on your back gas (in case, for some reason, you can't switch to the shallow mix). Keep in mind that a single gas computer may lock up due to omitted deco after a long second level, however, since it won't know you switched gases.

Planning Gas-Switch, Extended No Stop Dives Using Multigas Dive Computers. Using a multigas dive computer gives you maximum versatility with gas-switch, extended no stop dives. Choose the blends for the depth levels and enter them into the computer per manufacturer instructions.

Start with your deepest depth and blend. You switch gases on the computer after you ascend to the next level and NO TOX switch to the richer EANx. If you must switch back to back gas for some reason, you switch your computer and it automatically gives your new no stop times. Using a computer gives you more versatility in terms of depths, or needing to switch back and forth.

Although the multigas computer calculates automatically, you'll still want to use desk top deco software to assist with dive planning. Again, it's a good idea to carry a back up computer or tables. If these are single gas, they should be set or based on the lowest oxygen EANx (back gas).

Making Gas-Switch, Extended No Stop Dives More Conservative. Since you're using an increased fraction of oxygen to extend your bottom time instead of to pad your schedule, you need to use other techniques to make gas-switch extended no stop dives more conservative. The easiest way is the one you already know - stay well within no stop limits; ascend and switch well before reaching the deeper level limits.

You can also plan your dive based on EANx blends with somewhat less oxygen than you actually use. For example, you could plug in EANx30 and EANx40 in your desk top/multigas dive computer, but dive with EANx32 and EANx45 (making sure not to exceed the maximum depth for these blends). If you do this, you'll need to track oxygen exposure manually because the computer doesn't know what you're really breathing. You'll also need to calculate and plan oxygen exposure manually for repetitive dives.

With some multigas computers, if not inconsistant with the manufacturer's instructions, you can set the actual blends you're using, but set the computer for a higher altitude than actual. This renders more conservative no stop limits while tracking oxygen exposure accurately.

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Safety Stops Within Decompression Stops

As a recreational diver, you learned to make safety stops — a stop at 5 metres/15 feet for three to five minutes not required by your tables or computer for added conservatism. You can do the same thing as a tec diver on a decompression dive by over staying your last deco stop by five minutes. For example, if your table says you require nine minutes at 3 metres/10 feet, you stay 14. Or, if your computer clears you to surface, and you stay another five minutes. Doing this with oxygen, in particular, adds a good measure of conservatism.

After surfacing from a particularly strenuous dive or long deco dive, "safety stop" at the surface by resting in the water for another five to 15 minutes before exit.

After surfacing from a particularly strenuous dive or long deco dive, "safety stop" at the surface by resting in the water for another five to 15 minutes before exit. You may continue to breathe EANx or oxygen. Remember that even though you're at the surface, if you're breathing EANx50 or higher, the CNS clock is running and you're gathering OTUs; be sure to calculate these in your oxygen exposure.

Runtime

When following tables through a dive and decompression, the traditional method is to arrive at a stop, time it for the required minutes, go to the next stop, time it, and so on. *Runtime* is an easier way to handle your dive schedule. *Runtime* is a continuous elapsed schedule you follow from the beginning to the end of the dive when following a table. It accounts for your descent, ascent, and decompression time, and it tells you where you should be against elapsed time. Rather than time each depth and phase separately, you follow a continuous time. To use runtime, you simply *depart* from the depth when you reach the elapsed time listed for that depth, and head for the next depth at the predetermined ascent rate.

You create runtime by adding the times for each dive phase and deco stop in sequence, including ascent time (round minutes to closest whole minute, up or down). Usually, you include descent time in your bottom time.

By now you might be sick of hearing how desk top deco software makes life easier by all the things it does for you, and here's another one. Desk top deco software will generate runtime automatically, sometimes with less rounding. The programs sometimes repeat a depth to show arrival and departure times, but the concept's the same. When generating multiple tables, some programs will generate runtimes for alternative schedules as well as for your planned one. That way, you can use runtime in a contingency situation.

Here's an example of calculating runtime by hand: You're making a 30 minute dive to 30 m/100 ft using air and your table calls for a stop for one minute at 6 m/20 ft and 15 minutes at 3 m/10 ft. Your runtime would be:

Depth	Time	Runtime	How derived
0 m/0 ft	0	0	
30 m/100ft	30	30	(0 + 30)
6 m/20 ft	1	34	(30 + 3 min ascent + 1 min stop)
3 m/10 ft	15	49	(34 + 15 — ascent less than .5 minute ignored)

Runtime is simple to follow, but if you find yourself slightly ahead of runtime, (you leave the bottom a bit early for example), adjust to merge gradually with the runtime. For instance, using the previous runtime example, suppose you leave the bottom at 29 minutes instead of at 30. You merge by ascending slightly slower than usual so that you reach 6 m/20 ft in 3.5 minutes, and then stay 1.5 minutes at the stop to reach the 34 minute mark. Now you're on the runtime; ascend to 3 metres/10 feet and stay until runtime reach 49 (plus a safety stop if you want). If you get behind your runtime, you usually need to switch to the next longer decompression schedule.

Air breaks and gas switches when you return to back gas don't count as decompression time. You can handle this several ways. One is by using a dive watch with a stopwatch function and stopping the runtime during air breaks/gas switches. If you're calculating your runtime manually, the easiest thing to do is to add them into your runtime. Some desk top deco software will automatically add air breaks, but others won't and you have to put them in yourself.

Runtimes work well with gas-switch, extended no stop dives. Your runtime shows the point by which you must ascend from each deeper level to the next shallower level. If you go up ahead of the time indicated, no problem. The dive becomes more conservative than planned, so you can still follow the runtime without adjustments.

Gas Matching

In tec diving you'll hear a fair bit about *gas matching*, particularly in diving that involves overhead environments (caves and wrecks). Gas matching is a technique that accounts for teams with members who have different breathing rates and cylinder sizes. It helps assure that should the diver with the highest SAC rate and gas supply have complete gas loss at the furthest penetration point, a team mate with a lower gas supply volume and lower SAC rate have sufficient gas reserve for both divers to exit. The idea is for the diver with the smaller gas volume/lower SAC rate to reserve a volume equal to one-third of the *larger* gas supply.

Because you can usually ascend immediately or very soon in deep open water tec diving, gas matching isn't typically used in open water tec diving. However, if you become qualified to make wreck penetrations or cave/cavern dives, gas matching is very important.

For open water tec diving it's sufficient to determine your actual gas volume before each dive to be sure you have enough gas, plus reserve, to make the dive as planned. However, you may find it handy in situations in which you want to return to a particular point before ascending, such as along an anchor line when there's a moderate surface current. In this case, you might plan to come back before ascending, and gas matching provides the option of doing so if assisting a team mate with more gas and a higher SAC. (Obviously, you still should have your lift bag, deco cylinders and be prepared to ascend directly).

When gas matching, the diver with the larger volume and SAC rate plans to turn the dive upon reaching thirds (after using one third of the gas supply). Then, you use what you've already learned about determining tank base lines to match:

In metric:

1. Take the volume of the larger gas supply and divide by three. This is the amount that must be reserved by the diver with the smaller supply.
2. Divide the reserve by the capacity of the smaller gas supply cylinders. The result is the reserve pressure that the diver with the smaller gas supply should have left at the end of the dive if there's no emergency.
3. Subtract the reserve pressure from the actual pressure of the smaller cylinders, divide that by two, and subtract the result from the actual pressure to get the pressure turn around point for the smaller gas supply.

Example: You're diving with twin 11 litre cylinders with 200 bar. Your team mate has twin 21 litre cylinders with 160 bar. What should your reserve pressure be, and what's your one-third turn around pressure?

Answer: 102 bar reserve pressure; 151 bar turn around

Team mate's volume = 21 x 2 x 160 = 6720 litres
Reserve = 6720 ÷ 3 = 2240 litres.
reserve divided by your tank capacity = 2240 ÷ 22* =
102 bar reserve you should have left
200-102 = 98 bar you can use; 98 ÷ 2 = 49; 200 - 49 = 151
*22 because double 11 litre cylinders

In imperial:

1. Take the volume of the larger gas supply and divide by three. This is the amount that must be reserved by the diver with the smaller supply.
2. Divide the reserve volume by the base line of the smaller cylinders. The result is the reserve pressure the diver with the smaller gas supply must maintain.

3. Subtract the reserve pressure from the actual pressure of the smaller cylinders, divide that by two and subtract it from the actual pressure of the smaller cylinders to get the turn around point for the smaller gas supply.

Example: You're diving with twin 80 cubic foot cylinders, working pressure 3000 psi, with 2950 psi in them. Your team mate has twin 120 cubic foot cylinders, working pressure 2400 psi, with 2350 psi in them. What should your reserve pressure be, and what's your one-third turn around pressure?

Answer: 1473 psi reserve pressure; 2213 turn pressure

Team mate's baseline = .1 (240 ÷ 2400 = .1) ; Team mate's volume = 235 cf (2350 x .1); Team mate's reserve = 235 ÷ 3 = 78.3.
Your baseline = .053 (160/3000 = .053).
78.3 ÷ .053=1477; 2950 - 1477 = 1473, 1473 ÷ 2 = 736.5;
2950-737=2213

Depending upon logistics and the environment you're in, your instructor may have you gas match on your dives. Keep in mind that even if you don't need to gas match, you always need to determine actual gas supplies, reserves and turn points as you've learned already.

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Tec Exercise – 4.2

1. When making gas-switch, extended no-stop dives (check all that apply):
   - ☐ a. choose your second blend based on your second depth level.
   - ☐ b. after ascending to the second level and switching, you stay on the second blend for the rest of the dive.
   - ☐ c. it's crucial to observe the rule of thirds, or a more conservative reserve.
   - ☐ d. None of the above.

2. If you cannot switch to your shallower gas blend, or if you must switch back to the deeper blend when making a gas-switch, extended no-stop dive (check all that apply):
   - ☐ a. switch your multigas computer accordingly, if you're using one.
   - ☐ b. assume the whole dive was made on back gas if using tables.
   - ☐ c. stay within no stop limits.
   - ☐ d. None of the above.

3. When using desk top deco software to plan a gas-switch, extended no-stop dive, if in doubt about the second level's depth, plan a ___________ level as opposed to a ________ one.

4. Although the multigas computer calculates gas-switch, extended no-stop dives automatically, you'll still want to use ____ ____ _____ ______ to assist with dive planning.

5. To make a gas-switch, extended no-stop dive more conservative (check all that apply):
   - ☐ a. dive with gases that have less oxygen than those you planned the dive with.
   - ☐ b. set a multigas computer for a lower altitude than actual.
   - ☐ c. get as close as possible to the no stop limits.
   - ☐ d. None of the above.

Tec Exercise – 4.2 continued

6. To make a safety stop within a decompression stop, you over stay your required time on the last stop by five minutes (or more).
   ☐ True ☐ False

7. To use runtime, you simply _____ from the depth when you reach the elapsed time listed for that depth.

8. If you find yourself slightly ahead of runtime, you'll have to abandon the runtime and use the deco schedule for the next deeper depth and longer time.
   ☐ True ☐ False

9. Gas matching is a technique that accounts for teams with members who have different breathing rates and cylinder sizes.
   ☐ True ☐ False

Check it out:
1. a,b. c isn't correct because you're making a no stop dive and a less conservative reserve is usually acceptable. 2. a,b,c. 3. deeper, shallower. 4. desk top deco software. 5. d. 6. True. 7. depart. 8. False. If you're slightly ahead of runtime, adjust to gradually merge with it. 9. True.

Emergencies IV

In the last chapter you learned to handle possible emergencies, most of which could happen but are usually easy to prevent. Most of the emergencies in this chapter fall into the same category. If you emphasize good diving technique and adequate planning, you should never face most of these — but you should still know what to do, just in case.

TEC Objectives

Highlight or underline the answers to these questions as you find them:

1. How do you ensure that you don't lose your deco cylinders, and what should you do if you do?
2. What do you do if your dive goes deeper and/or longer than your planned dive?
3. How can you use a single gas dive computer to back up a multigas computer?
4. What should you do if you miss a decompression stop?
5. What should you do if you have a delay in your ascent to a decompression stop?
6. What should you do if you omit some or all of your decompression?
7. What should you do if you run out of gas?
8. What is a "drift kit," when you would you use it and what items would you have in it?
9. How do you handle a lift bag that spills as it ascends but cannot be pulled back down to redeploy?

Lost Decompression Cylinders

Losing your deco cylinders can leave you without a complete solution, so this is definitely a problem with the emphasis on prevention. Never stage your cylinders if you have any question whether you'll be able to return to them and retrieve them. Be cautious at popular dive sites so you don't stage cylinders where other divers might take the "lost" tanks they "found." When you leave them, be sure they're where they won't roll, float or get swept away. Clip them to something or otherwise secure them if possible. As you learned, confirm that the valve's closed, but the regulator pressurized, on the staged cylinder before you leave — an empty cylinder's no more useful than a lost one.

If you do lose your cylinders, how difficult your situation is depends on how much decompression you have and whether it's based on accelerated decompression or not. The primary issue will be whether you have enough gas volume to decompress adequately.

If you're following a single gas table or computer and using deco cylinders with higher oxygen for conservatism, then you can decompress on back gas. Provided you have enough volume, you give up the conservatism but you should still decompress adequately.

If you're making an accelerated decompression, you can carry single gas back up tables (desk top deco software), or (multigas computers) keep the computer set for your back gas. The problem here is that accelerated deco dives tend to be long dives with lots of decompression in the first place, so you may not have enough gas to complete your decompression.

With support divers, things may be easier. They may be able to bring down standby cylinders, or to locate your missing cylinders. When making accelerated deco dives, if using a multigas computer and your team mates have not lost their deco gases, they can give you what's left of theirs as they finish. They'll finish before you, but you should be able to complete your decompression.

If you don't have enough gas in your doubles to complete your decompression, decompress as long as you can. When you surface, breathe emergency oxygen and contact emergency medical care if you suspect DCI (either DCS or AGE) symptoms.

Exceeding Your Planned Depth/Time

Good buoyancy control and control in the water should make this a rare situation, and should it happen, it shouldn't be an "emergency" so much as a "situation." You should prepare for this as a regular part of dive planning (as you've already been practicing).

For tables-based dives, desk top deco software will generate a table series based on times and depths less than and greater than your planned time and depth for contingency purposes. Dive computers will automatically calculate based on your actual dive profile. The rule of thirds will generally accommodate the next longer/deeper schedule, but you should compare the gas requirements to be sure.

Be prepared to alter time to accommodate depth. If you find yourself deeper than planned, turn the dive sooner. Precision diving is the key — you must master buoyancy control and closely monitor depth, time and gas supply. Dive well and this won't be an issue.

Backing Up A Multigas Computer with a Single Gas Computer (Continued)

As you learned, you back up a multigas computer with a single gas computer by setting the single gas computer for your back gas. Decompress as if using back gas, with the higher oxygen blends for conservatism. That's pretty straightforward.

How Do I Figure 1.5 Times With a Computer?

Supposed you're following a computer based decompression and have to follow the procedure for extending the 6 metre/20 foot and final stops by 1.5 because you had to assist a team mate and went above your stop depth for two minutes. The problem is that when you overstay the 6 metre/20 foot stop, the computer shortens what it predicts for your final stop (5 metres/15 feet or 3 metres/10 feet) — but, you need to stay for 1.5 times the original time.

Do this: Stay at your 6 metre/20 foot stop until the computer clears you to the last stop. Immediately note the decompression time remaining on your slate, and the elapsed bottom time, but do not ascend. Instead, stay at 6 metres/20 feet until you complete the 1.5 times the 6 metre/20 foot stop time, which either the computer tells you, or if not (some only show total deco time remaining), you determine by noting the beginning and ending elapsed bottom time.

After you complete that, ascend to the final stop for 1.5 times the remaining deco time you noted on your slate.

Example: You're following the procedure and your elapsed bottom time is 56 minutes when you reach 6 metres/20 feet. At 66 minutes, the computer clears you to the final stop and shows 24 minutes of decompression remaining. You stay at 6 metres/20 feet for an additional five minutes (1.5 x 10 minutes). Then ascend to the final stop for 36 minutes (1.5 x 24 minutes).

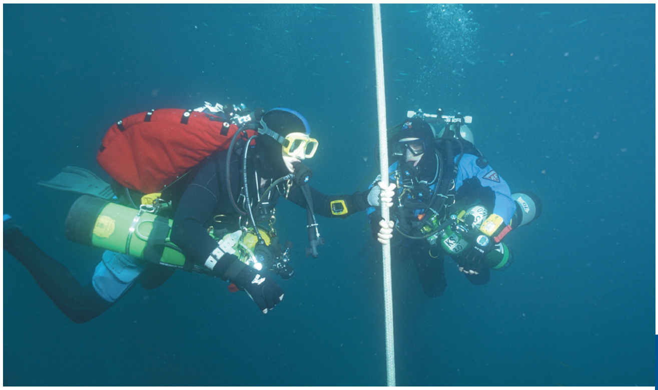
Note: Some computers automatically calculate missed deco stop procedures. See the manufacturer's instructions.

However, circumstances might require accelerated decompression. This could be due to water temperature or because you can't decompress on the back gas schedule because you don't have the gas volume require. In this case, you need to carry accelerated deco tables (generated by desk top deco software) and use the single gas computer (or a depth gauge/timer) for time and depth information only.

Missed Decompression Stop

This emergency usually results from another emergency, such as a gas shortage forcing you to skip a stop and ascend shallow enough to switch to your next, richer oxygen blend. If you're diving with care and precision, it shouldn't happen by accident by itself.

If you miss a decompression stop, how you handle it depends on the situation. If you can, immediately (within one minute) redescend and complete the stop, plus one minute, and then decompress according to the normal schedule. This might be an instance in which, for example, you assist an overly buoyant diver stop an ascent.



If you miss a decompression stop, how you handle it depends on the situation. If you can, immediately (within one minute) redescend and complete the stop, plus one minute, and then decompress according to the normal schedule. This might be an instance in which, for example, you assist an overly buoyant diver arrest an ascent.

If you cannot redescend (such as with the gas supply problem), stay at the next stop for the combined time of both stops. Extend your 6 metre/20 foot stop and your final stop by 1.5 times the normally scheduled decompression. If you're using a dive computer, it may lock up if you skip a stop and cannot redescend to complete it. You may need to decompress according to back up tables.

Delay in Ascent to Decompression Stop

Variations in ascent aren't unusual, but you shouldn't typically have a substantial delay. The simplest action is that if you're delayed ascending to your first decompression stop, add the delay to your bottom time and decompress according to the new schedule. Between stops delays aren't usually as critical unless they're excessive (more than two or three minutes). Do not count the delay as decompression time when you resume decompression.

When diving with a computer, the computer calculates in delays automatically, extending decompression if necessary, so you need only continue to follow the computer's deco schedule. When you've had a delay in ascent, it's always wise to extend your last stop as much as practicable.

Omitted Decompression

As with missing a stop, omitted decompression should only happen when another emergency causes it to happen. Divers who omit stops because they can't maintain a stop depth or because they can't follow a schedule need more experience and training before they take up tec diving. The seriousness of omitted decompression depends on the situation. It can be minor to life-threatening.

If you omit decompression from 6 metres/20 feet or shallower, and you have no DCS symptoms but it takes longer than one minute to return to your stop depth, extend your 6 metre/20 foot stop and/or the final stop by 1.5 times the decompression normally required (or longer on the final stop, as possible). This might be the case if you have to surface for more deco gas due to an emergency.

Omitting all required decompression has high DCS risk, especially if it's greater than five or ten minutes. The more decompression you've completed, the less risk (obviously). If decompressing with a single gas computer/table and using EANx/oxygen for conservatism, your risk is relatively low if you've completed most of your decompression.

If you omit decompression from 6 metres/20 feet or shallower, if you have no DCS symptions and it's possible, return to depth within one minute and complete your decompression as scheduled. As a precaution, extend your last stop several minutes or more.

If you omit decompression from 6 metres/20 feet or shallower, and you have no DCS symptoms but it takes longer than one minute to return to your stop depth, extend your 6 metre/20 foot stop and/or the final stop by 1.5 times the decompression normally required (or longer on the final stop, as possible).

If you omit decompression from deeper than 6 metres/20 feet, return to the first stop depth as quickly as possible (ideally less than five minutes) and decompress according to schedule up to and including the 12 metre/40 foot stop. Extend the 9 metre/30 foot stop and all shallower stops by 1.5 times their scheduled times.

If you cannot return to depth (no gas available, for instance), breathe emergency oxygen, remain calm and monitor yourself for DCS symptoms. If you surfaced owing more than a few minutes decompression or skipped all your decompression, assume you will get bent and have your team begin preparing for emergency evacuation. Stay on 100 percent oxygen until reaching emergency medical care.

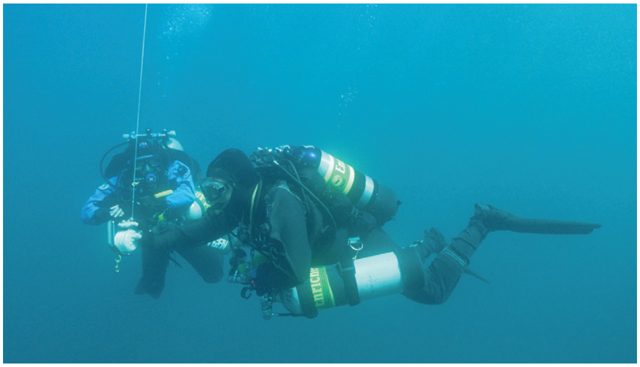
Running Out Of Gas

Running out of gas by breathing it down should not occur if you plan your reserve appropriately and turn your dive at the right point. Unexpected exertion or a sudden freeflow can cause you to exhaust gas faster than expected, even with a quick valve shutdown, but normally your reserve should cover these problems. You should not run out of gas on the bottom because you should be ascending to your first stop depth before that happens. However, it is possible to have a gas shortage and perhaps run out following a severe, difficult to control gas loss, such as a manifold failure when you're almost at your turn point.

Your first option is to see if your team mates or support divers can help by sharing gas or bringing some down. If you exhaust a deco gas using tables, ascend to the first stop where you can use your next gas. Combine missed stops with the stop at that depth, unless this will prematurely exhaust that gas, too. In that case, follow the decompression schedule and extend the shallower stops as much as practicable.

If you exhaust a deco gas using a single gas computer or table, simply complete decompression on back gas, (you have to have enough volume to do so, of course). If you exhaust a deco gas using a multigas computer, switch to back gas and select that gas on the computer. Decompress on the new schedule the computer provides. The more decompression you complete before you exhaust the deco cylinder, the more likely you'll have sufficient back gas volume to complete your decompression.

As a general guideline, if gas termination interferes with your decompression, decompress as long as you can as best you can with what you have. Stay down



As a general guideline, if gas termination interferes with your decompression, decompress as long as you can as best you can with what you have. Even if you end up getting DCS, the more decompression you completed, the less severe it should be.

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with team mate's high oxygen deco cylinders after they complete decompression, if possible. Even if you end up getting DCS, the more decompression you completed, the less severe it should be.

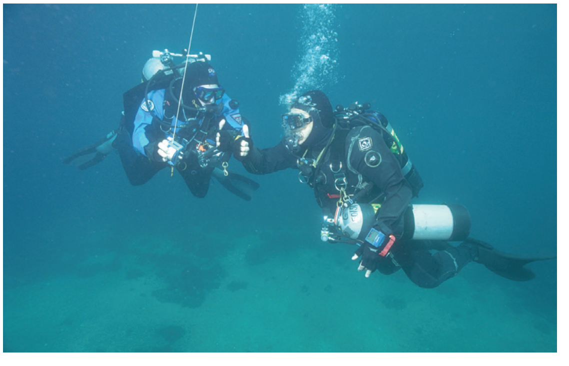
Drift Kits

A possible risk in open ocean diving, or even in some major lakes, is ending up adrift in the current a considerable distance from the boat. If diving where this could happen, you should carry a drift kit, which is a kit with emergency items. The most elaborate are watertight/pressure proof containers bracketed to the doubles; the simplest are items in a pocket or pouch.

You use your drift kit if you surface and cannot see the dive boat, or it is too far away to reach and you're having trouble getting the crew's attention. At a minimum a drift kit contains an inflatable signal tube (safety sausage) and a whistle. In higher risk current environments, you may consider adding a signal mirror, watertight flasher, and for the highest risk environments, a portable EPIRB (Electronic Positions Indicating Radio Beacon — allows authorities to find you electronically when activated) in a pressure proof casing. Flares, smoke flares and aircraft dye markers can also make you easier to spot for pickup. In areas with cell service that extends well out over the water, some divers carry mobile telephones in small underwater housings so they can ring up help if they need to!

Partly Spilled Lift Bag

If you send up a lift bag without sufficient line tension, it can partly spill at the surface, leaving it too buoyant to pull down and redeploy, but insufficiently buoyant for use as a firm decompression line. Your first option is to send up a team mate's lift bag clipped to the *same* line via a carabiner or large bolt snap (small snaps can hang up). Using the same line combines their lift and avoids entanglement from two lines in water.



If you can't pull a partially spilled bag down, then there's sufficient buoyancy to use the bag as is. You'll need to be careful with your buoyancy, but you should be able to decompress along the line adequately.

As a second option, your team mate deploys a lift bag entirely separately. This means there are two lines to deal with, but it's an option if you have some doubt about what's going on with the line. Finally, if you can't pull the bag down, then there's sufficient buoyancy to use the bag as is. You'll need to be careful with your buoyancy, but you should be able to decompress along the line adequately.

Tec Exercise – 4.3

1. If you lose your deco cylinders (check all that apply):
   - ☐ a. how difficult your situation depends on how much deco you have.
   - ☐ b. if using a single gas table/computer, decompress on back gas.
   - ☐ c. your team mates may be able to give what's left of their gases.
   - ☐ d. if all else fails, decompress as long as you can with whatever gas you have.

2. You should prepare for your dive going deeper and/or longer than planned as a regular part of _______ ________.

3. If circumstances require accelerated decompression when using a single gas computer to back up a multi-gas computer, you should carry ________ ____ ______ and use the single gas computer only for depth and time information.

4. If you miss a decompression stop (check all that apply):
   - ☐ a. if possible, immediately redescend and complete your stop.
   - ☐ b. stay at the next stop for the combined time of both stops.
   - ☐ c. extend your final stop by ten minutes or more.
   - ☐ d. None of the above.

5. To handle a delay while ascending to a decompression stop (check all that apply):
   - ☐ a. if ascending to first stop, add delay to bottom time and deco on new schedule.
   - ☐ b. do not count delays between stops as decompression time.
   - ☐ c. follow your computer's schedule if you're using one.
   - ☐ d. it's wise to extend your last stop as much as practicable.

6. To handle omitted decompression (check all that apply):
   - ☐ a. if no DCS symptoms, return to depth within five minutes and complete your decompression, then extend your last stop as long as you can.
   - ☐ b. if you can't return to depth, breathe emergency oxygen and monitor yourself for DCS symptoms.
   - ☐ c. you don't need to worry much if you omitted one hour or less decompression.
   - ☐ d. None of the above.

7. If you run out of gas underwater (check all that apply):
   - ☐ a. see if your team mates or support divers can share gas.
   - ☐ b. if possible, ascend to the first stop at which you can switch to the next gas.
   - ☐ c. finish using back gas, if possible and if using a single gas computer or table.
   - ☐ d. if all else fails, decompress as long as you can with whatever gas you have.

8. Items you might carry in a drift kit include (check all that apply):
   - ☐ a. inflatable signal tube
   - ☐ c. EPIRB
   - ☐ b. signal mirror
   - ☐ d. whistle

9. If your lift bag partially spills but you can't retrieve and redeploy it, your first option is
   - ☐ a. to have your team mate send up a separate bag and line.
   - ☐ b. to live with it as it is.
   - ☐ c. to wait for a support diver to reinflate it.
   - ☐ d. to send a team mate's bag up on the same line for additional flotation.

Check it out:
1.a,b,c,d. 2. dive planning. 3. accelerated deco tables. 4. a,b,c. 5. a,b,c,d. 6. a,b. 7. a,b,c,d. 8. a,b,c,d. 9. d.

FOUR

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What do tec divers mean when they say they "never stop learning"?
2. What four attitudes characterize leading tec divers?
3. What is the biggest myth told about diving with certain methodologies or in certain environments?
4. Why is methodology situational?

Thinking Like a Tec Diver IV

As tec diving continues to evolve, new technologies and methodologies arise quickly. Competent tec divers recognize that their learning never stops. Besides continuing their education in diver training courses, they avidly read dive magazines, underwater scientific and technical literature, and other information sources that bring new developments into undersea exploration.

Successful tec divers pay attention to new ways of doing things as they meet and interact with different tec divers from different locals and environments. They analyze each dive after the fact and make a conscious effort to distill new learning from it. Tec divers say "They never stop learning," meaning that your education in technical diving never ends, and that every tec dive is part of it.

Four Attitudes Characterize Leading Tec Divers

In considering your growth as a tec diver, it's worth noting the characteristics tend to typify leaders in not just tec diving, but in most areas of exploration:

Humility. They realize that they don't know everything, and that there may be more than one right way to do something. Their ego doesn't get in the way of learning, doing or teaching.

Open Mindedness. They never reject something just because it's new or different, and they listen to other viewpoints. They don't fear change and they're not threatened by differing opinions.

Analytical. They accurately and realistically weigh the merits of a technology or procedures for themselves and never accept something just because it's new or because someone else thinks it's better

Competent. While they're open to change and alternative ways to do things, their own methodologies are solid and they can demonstrate a rationale and realistic basis for each. They're quietly confident about how they dive.

The Biggest Myth in Diving

The biggest myth in diving (tec or recreational) is that learning to dive in a specific environment or with a specific methodology quali-

The suggestion that mastering one methodology or environment meets all diving circumstances presupposes that the methodology addresses all possible variables, or that the environment imposes all possible variables. This isn't possible. No environment can be both tropical and polar, lake and ocean, etc.

fies you to dive everywhere. There is no such environment. There is no such methodology.

Methodology and its supporting technology are, to varying extents, situational because each situation imposes differing demands. For instance, a three hour dive in 27°C/80°F water wouldn't require a dry suit, whereas in 10°C/50°F water it definitely would. Using a dry suit, as opposed to not, dictates differing diving techniques — so here at the most basic level (you're not even looking at tec diving specifically yet), methodologies differ.

The suggestion that mastering one methodology or environment meets all diving circumstances presupposes that the methodology addresses all possible variables, or that the environment imposes all possible variables. This isn't possible. A deep lake dive may be very cold, dark and eerie, but it probably doesn't have the challenge of oceanic currents. Opposite conditions have their own challenges — no environment can be both tropical and polar, lake and ocean, etc.

The basic methodologies and configurations you learn in this course form the foundation for a wide variety of technical diving circumstances. However, you must learn specifics for the tec environment you actually dive from your instructor, the local tec community and from experience gained by broadening your limits slowly and carefully over many dives. And, when you go to tec dive in another environment, as you've learned you'll need to learn the specific procedures and requirements for that environment.

Tec Exercise – 4.4

1. When they say they "never stop learning," tec divers mean that your ____________ as a tec diver never __________.
2. F our attitudes that characterize leading tec divers include (check all that apply):
   - ☐ a. humility
   - ☐ b. narrow mindedness
   - ☐ c. analytical
   - ☐ d. critical
3. The biggest ______ in diving is that learning to dive in a specific environment or with a specific methodologies qualifies you to dive _________.
4. Methodology is situational because no environment can impose all possible _________.

***Check it out:** 1. education, ends. 2. a,c. 3. myth, everywhere. 4. variables.*

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan Training Dives Six and Seven by appropriately and accurately accounting for logistics, runtime, gas requirements for each diver, OTUs, CNS% and maximum depth based on personal SAC rates, dive profiles, gas blends to be used, environmental details and other information provided by the instructor as necessary about the dives.

Preview: Practical Application Four

During this practical application, you'll work in teams to plan Training Dives Six and Seven based on information your instructor provides. Consider A Good Diver's Main Objective Is To Live and refer back to this manual as you plan. They will both be gas-switch, extended no-stop dives. Dive Seven will include simulated decompression stops at 6 metres/20 feet and 3 metres/10 feet.

Your instructor will provide the basis for determining your deco schedule and have you calculate, OTUs and CNS for each diver and gas, plus gas requirements including one-third reserve, actual gas supplies, turn points, equipment requirements, logistics, emergency procedures and other information from the A Good Diver's Main Objective Is To Live planning process.

Your plans should contain all information you would need to make the dives.

You will also complete Exam One as part of your practical application. You must complete the exam independently (it's not a team exercise), and may use scratch paper, a calculator and the tables in the appendix of this manual. Note that you will be required to turn in the scratch paper with your calculations for the dive planning problems. You must successfully complete the exam prior to Training Dive Six.

A Word for the Apprentice Tec Diver

If you're taking the Apprentice Tec Diver portion of the Tec Deep Diver course, successfully completing Exam One and Training Dives Six and Seven marks the end . . . for now. Congratulations for accomplishing so much.

"Apprentice," that is, "one who is learning," tells you that the Apprentice Tec Diver course is not, nor was never meant to be, the completion of your training. Rather, the Apprentice Tec Diver course opens the door for those who have the background to begin training, but lack the qualifications to complete training.

Your Apprentice Tec Diver certification qualifies you to apply some new skills. You're qualified to use up to EANx60 to make gas-switch, extended no-stop dives, and to pad your safety stops.

Obviously you're qualified to make no stop dives in tec gear.

At the same time, it's worth remembering that you're not yet qualified to make decompression dives, even though you've begun to learn a bit about it. But there's still more to learn, and more skills to develop before attempting technical decompression dives. And, by now you know better than to tempt fate by attempting dives you're not trained and qualified for.

Be patient. Gain experience in as many different environments as you can. Listen and learn. When you complete the prerequisites necessary for picking up here and completing the rest of the Tec Deep Diver certification, you'll be ready, and have the experience you can apply.

Preview: Training Dive Six

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Execute a real or simulated gas-switch, extended no stop decompression dive.
3. Beginning approximately one to two metres/three to six feet off the bottom and neutrally buoyant, commence and swim at least 18 metres/60 feet sharing gas with the long hose, as both the donor and receiver, without making any contact with the bottom.
4. Respond to a simulated BCD failure by switching to back up buoyancy control, attaining neutral buoyancy, then ascending approximately 3 metres/10 feet and re descending to within one metre/three feet of, but not touching, the bottom by maintaining neutral buoyancy.
5. As a team, deploy a lift bag, ascend along its line and perform a 15 minute safety stop/simulated decompression stop (gas allowing) at 3 metres/10 feet.
6. While making a safety stop/simulated decompression stop with a line as a reference, perform the gas shutdown drill while maintaining buoyancy control and not ascending or descending from stop depth more than one metre/three feet.
7. Demonstrate time/depth/gas supply awareness by recording on a slate the time and SPG reading at each 15 minute interval.

Predive briefing and gearing up

Training Dive Six

- Record depth and SPG reading at each 15 minute interval throughout the dive.

  Entry — appropriate for environment

  Weight check (if needed)

  Bubble check

  Don stage cylinders at surface

  Descent

  Descent check

  Stage cylinder at second level (*if appropriate*) — continue to deepest level.

    Ascent to second level and NO TOX switch at interval required by dive plan.

  Long hose drill, no bottom contact

  BCD failure drill

  Free time in general area for experience and practice

  Deploy lift bag from second level.

    Ascend along lift bag line and make 15 minute safety/simlated deco stop.

  Air break practice — break for two minutes after 10 minutes.

  Gas shutdown drill while neutrally buoyant at stop

  Surface — remove stage cylinder at surface

  Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Preview: Training Dive Seven

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan the dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Successfully perform a gas-switch, extended no stop dive with a 30 minute safety/simulated decompression stop at 6 metres/20 feet.
3. Retrieve a stage/deco cylinder that has been staged and while continuing to swim, don it.
4. Respond properly to a simulated computer or primary decompression information failure by completing the dive using the back up system, as included in the predive planning process.
5. As a team, deploy a lift bag and ascend its line to 6 metres/20 feet, switch to a decompression cylinder following the NO TOX procedure and make a 30 minute safety/simulated decompression stop at that depth.
6. Perform the gas shutdown drill while neutrally buoyant without varying more than one metres/three feet from the stop depth.
7. Demonstrate time, depth and gas supply awareness by writing the SPG reading and depth on a slate a specific bottom time assigned by the instructor.

FOUR

Predive briefing and gearing up

Training Dive Seven

- Record depth and SPG reading at instructor-specified interval throughout the dive.

  Entry — appropriate for environment

  Weight check (if needed)

  Bubble check

  Don stage/deco cylinders at surface

  Descent

  Descent check

  Stage cylinders at deco level and at second level (if appropriate) — continue to deepest level.

  Group stays together and explores; free time.

  Ascent to second level.

  Retrieve stage cylinder on fly, NO TOX switch.

Free time in general area for experience and practice

Computer failure drill

Deploy lift bag from second level.

Ascend along lift bag line, NO TOX switch at 6 metres/20 feet — 30 minutes safety/simulated deco stop

> Air break practice — break for five minutes after 25 minutes.

Gas shutdown drill while neutrally buoyant at stop

Surface — remove stage/deco cylinders at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

KNOWLEDGE Review – Chapter Four

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. Explain the difference and give examples of acceptable and unacceptable homemade gear. What's probably the most common homemade item used by tec divers?

2. Explain how to plan and make a gas-switch, extended no-stop dive using desk top decompression software.

3. Explain how to plan and make a gas-switch, extended no-stop dive using a multigas dive computer.

4. Explain what you should do if you cannot switch to your shallower gas blend when making a gas-switch, extended no-stop dive.

5. How do you make a safety stop within a decompression stop?

FOUR

KNOWLEDGE Review – Chapter Four

6. What's runtime? How do you use it?

7. What should you do to ensure you don't lose your decompression cylinders?

8. What do you do if your dive goes deeper and/or longer than planned?

9. What should you do if you miss a decompression stop?

10. What should you do if you have a delay in your ascent to a decompression stop?

11. What should you do if you omit some or all of your decompression?

KNOWLEDGE Review – Chapter Four

12. What should you do if you run out of gas?

13. What is a "drift kit," when you would you use it and what items would you have in it?

14. How do you handle a lift bag that spills as it ascends but cannot be pulled back down to redeploy?

15. What is the biggest myth told about diving with certain methodologies or in certain environments? Why isn't it true?

FOUR

KNOWLEDGE Review – Chapter Four

16. Gas Matching (optional exercise): You're diving in double 18 litre/104 cubic foot (working pressure 2400 psi) cylinders filled to 150 bar/2200 psi. Your team mate will use double 21 litre/120 cubic foot (working pressure 2400) cylinders filled to 160 bar/2350 psi. If you gas match, what pressure should you have remaining at the end of the dive (assuming no emergencies), and at what pressure should you turn the dive?

Student Diver statement: I've reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date ___________

Survival
depends on being able to suppress anxiety
and replace it with calm, clear, quick and correct
reasoning.

— **Sheck Exley,** cave diving pioneer, 1949-1994

Chapter FIVE: The Refinements

Chapter Five introduces new information to you, but you should find it fairly easy to learn. At this point, you're *refining* what you know based on what you've learned in previous chapters. Some of what this chapter discusses will seem like a review — that's as it should be.

You'll start out looking at, yes, more about *gas planning*, with an emphasis on oxygen, the "oxygen window," and why oxygen has so many advantages over EANx when decompressing. After that, you'll look quickly at the techniques involved with making decompression dives in a current, followed by handling the *emergency* of an unresponsive diver at depth — something you've already looked at to some extent in the discussion on how to handle a convulsing diver underwater. Then you get more on *thinking like a tec diver*, with a look at the rescue philosophy and more on how your thinking can prevent problems. Finally, a section on *mission planning* takes you into getting something done while you're down there — the whole point of what you're learning to do!

Gas Planning V

Oxygen Window and Accelerated Decompression

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is the "oxygen window"?
2. How does the "oxygen window" relate to accelerated decompression?
3. Why is it that when decompressing with 100 percent oxygen, you can complete the decompression time for a 3 metre/10 foot stop as deep as 6 metres/20 feet without having to adjust your decompression time for the depth change?
4. How do you use desk top decompression software and/or multigas computers to calculate accelerated decompression dives?
5. How do you plan back up decompression information for an accelerated decompression dive?
6. How do you choose which gas blends to use for an accelerated decompression stop?
7. What are "deep stops," how do you apply them, and what might the benefit be of doing so ?

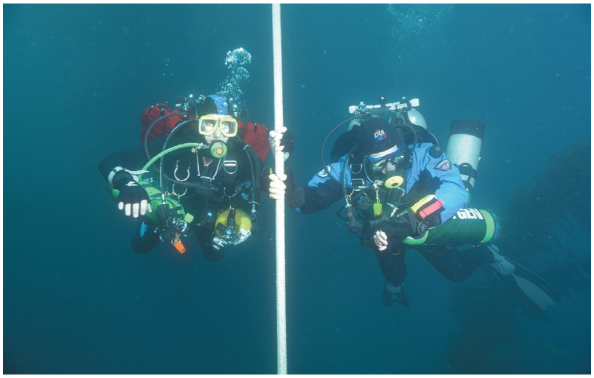
As you've learned, switching to a high oxygen EANx or 100 percent oxygen when you decompress accelerates your decompression time, largely because the body consumes oxygen through metabolism and other reactions. It doesn't contribute substantially to DCS, so from a decompression point of view, it can be ignored (within limits well within anything that applies to real diving).

When you ascend, as you recall, the drop in ambient pressure causes a pressure differential (gradient) between the pressure of the dissolved inert gas (nitrogen) in your tissues and the pressure of the inert gas in your lungs. This is what causes the nitrogen to dissolve out of your tissues. However, as you know, you can't ascend too far (on a decompression dive) or the ambient pressure drops so much that nitrogen may form bubbles in your tissues before it can dissolve harmlessly out through circulation and the lungs.

The shift to a higher oxygen gas or pure oxygen during ascent and/or decompression, creates a higher gradient (pressure difference) between the dissolved inert gas (nitrogen) in your tissues and in your lungs. This oxygen-derived gradient is called the *oxygen window*. Oxygen contributes to DCS only minimally, so the gas diffusion is one way — out of the tissues. This is the basis for accelerated decompression.

This becomes really obvious if you look at it on an EAD basis. Suppose your first decompression stop is at 9 metres/30 feet. If you switch to EANx50 at that depth, your EAD is two metres/seven feet. Therefore, nitrogen leaves your body as if you were only two metres/seven feet deep breathing air. But, *actually* ascending that shallow, would probably cause DCS.

This is more than a little bit of an advantage. From a practical point of view, accelerated decompression reduces your exposure to cold water and boredom. From a theoretical point of view, for a given decompression model, the shorter the *required* decompression, the more reliable it is. So, using EANx and oxygen to shorten your required decompression reduces your theoretical risk. And, you can enjoy these advantages while still padding your schedule to make it more conservative. But, accelerated decompression is never as conservative as switching to EANx or oxygen while following a single gas (air) decompression schedule.



The greatest oxygen window comes from breathing pure oxygen; the EAD is always minus 10 metres/ minus 33 feet and you're releasing nitrogen faster than if you were at the surface breathing air.

Oxygen in Particular. Decompression with 100 percent oxygen offers some practical decompression advantages over enriched air. The greatest oxygen window comes from breathing pure oxygen (at 6 metres/20 feet and shallower due to oxygen toxicity concerns, of course). Note that with 100 percent oxygen, the EAD is **always** *minus* 10 metres/ *minus* 33 feet and you're releasing nitrogen *faster than if you were at the surface breathing air*. This means that using 100 percent oxygen, for practical purposes you release nitrogen at the same rate, no matter what your depth.

This means you have flexibility in choosing your decompression stop depth. When using 100 percent oxygen, you can complete stops that are supposed to be shallower than 6 metres/20 feet at 6 metres/20 feet without having to recalculate the decompression time. With any EANx, a stop depth change alters the decompression requirements. But, note that you *cannot* ascend from the 6 metre/20 foot stop earlier than scheduled just because you're using oxygen.

This can provide logistical advantages, because staying deeper allows you to stay in calmer water if it's rough, or below traffic if you have unexpected boats criss-crossing above. You may have the perfect decompression spot to rest and relax at 6 metres/20 feet, but nothing at all at 3 metres/10 feet — so you just stay.

There's also some theoretical benefit to staying a bit deeper than the typical last stop of 3 metres/10 feet. Using 100 percent oxygen, it's typical to ascend to 5 metres/15 feet for the 3 metre/10 foot stop time. This keeps you deeper than 3 metres/10 feet but drops the PO_2 to keep your oxygen exposure somewhat more conservative compared to 6 metres/20 feet. A 5 metre/15 foot stop has become common in place of the 3 metre/10 foot stop to the point that even when not using oxygen, you can take your stop at 5 metres/15 feet when using a dive computer, or by setting your desk top deco software to create the final stop at 5 metres/15 feet instead of 3 metres/10 feet. (This is why you've been making 5 metre/15 foot stops in training dives.)

Planning Accelerated Decompression Dives. As you probably know by now, to plan an accelerated decompression dive you're going to use desk top deco software and/or a multigas computer. It's much like calculating a gas-switch, extended no stop dive — actually simpler with most desk top deco software.

When making an accelerated decompression dive with a multigas computer, you simply enter the gases you'll be using and then tell the computer when you're using what during the dive.

With most software, you enter your bottom depth, time and gas, and also enter the blend or blends (or pure oxygen) you'll use during decompression. The software generates your deco tables showing you gas switches, times, etc. You compare depth/time possibilities until you find the combination that's workable with the gases and volumes you have available. With a multigas computer, you simply enter the gases you'll be using and then tell the computer when you're using what during the dive.

Watch gas supplies closely; you have a shorter decompression compared to a single gas profile, but you *must* have sufficient volume of each deco gas to decompress adequately. It's best to have desk top deco software to estimate what schedule you get from your multigas dive computer, because with most multigas computers there's no way to easily determine what the deco requirements will be.

If you're stuck using a multigas computer without desk top deco software, then plan your dives based on your back gas — planning as a single gas dive with respect to the gas volumes you take — but then noting the actual deco times on the dive when you switch. Keep these in your log book and stick with the same deco gases as much as possible. Over time, you'll learn to estimate how much you need to take of each gas to complete your deco and still surface with one third of each gas remaining.

Again, with air, enriched air and oxygen, the optimum way to plan an accelerated decompression dive is to use a multigas computer on the dive and plan with desk top deco software.

Making Accelerated Deco Dives More Conservative. Although accelerated decompression gives up the "pad" of basing your dive on a single gas computer or table and then switching to higher oxygen, you can still pad your schedule for added conservatism. When following tables generated by desk top deco software you can:

- use the tables for the next greater depth and/or time than actually called for.
- generate the tables based on blends with less oxygen than actual (note that you will need to determine actual max depths and oxygen exposure).
- make a safety stop within the last decompression stop.

When using a multigas computer you can:

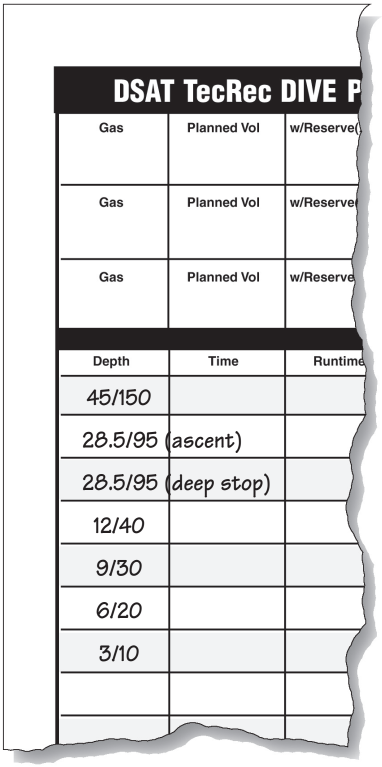
- set the computer for an altitude higher than actual.
- set the blends for less oxygen than actual (note that you will need to determine actual max depths and oxygen exposure yourself)
- stay well within all limits given by the computer.
- make a safety stop within the last decompression stop.

Planning Back Up For Accelerated Decompression Dives. A drawback to an accelerated deco dive compared to one based on a single gas is that you *must* have your deco cylinders to decompress. This adds another dimension to contingency planning. At the simplest, you can use desk top deco software to write alternative emergency tables for doing your hang without your deco cylinders. With multigas computers, you simply stay on the blend you're using.

In lost gas situations, however, it's quite possible that you won't have enough gas to complete your decompression. If so, accounting for this and planning for it is crucial in going through A Good Diver's Main Objective Is To Live. If there's any doubt, it's less risk to keep your deco cylinders with you because you *must* have them. In some instances, you can plan your dive as a single gas dive and take sufficient back gas to complete the decompression. Then, you dive following the accelerated decompression schedule; if you have a problem, your contingency plan is to use the single gas schedule.

Choosing Deco Blends. Using desk top deco software, you'll find that the shortest decompression comes from switching to the highest possible oxygen at each stop. If you have four stops, that would mean four different gas blends — but that's usually impractical and you usually don't gain much for having to haul four cylinders instead of one or two.

For dives to 50 metres/165 feet, you seldom benefit much by having more than two deco blends. For shorter dives, a deco single cylinder may be fine. Remember the KISS (Keep It Super Simple) principle — simpler is usually better, especially if taking one cylinder versus two, or two versus three, only means a few more minutes deco time. It's that much less to haul and deal with. Remember that you and your team mates want to use the same or compatible blends.



DSAT TecRec DIVE P

Gas	Planned Vol	w/Reserve(
Gas	Planned Vol	w/Reserve
Gas	Planned Vol	w/Reserve

Depth	Time	Runtime
45/150		
28.5/95 (ascent)		
28.5/95 (deep stop)		
12/40		
9/30		
6/20		
3/10		

Listing your deep stop and ascent at the midpoint between your bottom depth and the first stop.

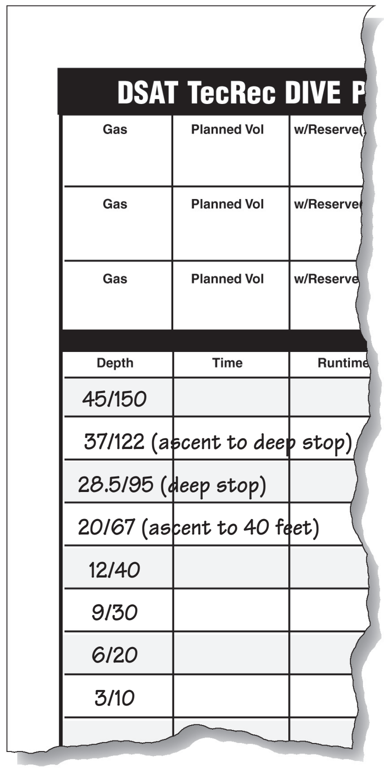
Deep Decompression Stops

In recent years, anecdotal evidence suggests that planning a deeper stop than normally required when making a decompression dive enhances the effectiveness of the decompression. This is a called a deep stop. While this appears to relate most directly to diving with helium blends, the practice has been adopted by most tec divers even when making air and enriched air dives.

You make a deep stop for two minutes at the halfway point between the bottom depth and the first "required" deco stop. For example, if you were diving at 45 metres/150 feet and your first stop is at 12 metres/40 feet, you make a deep stop at 28.5 metres/95 feet. Note that this exactly the same way you find the midpoint you use for calculating your ascent from the bottom to the first required stop.

If you make your deep stop on your bottom gas, you typically list the ascent and the deep stop separately (different SAC rates) on the dive planning workslate, though the same depth.

If you make a gas switch at the deep stop, calculate ascent based on the midpoint from the bottom to the deep stop, then the midpoint between the deep stop to the first required stop. (See example) This gives you three different depths between the bottom and the required stop. Do this if you change gases at your deep stop, which affects your oxygen exposure and gas requirements.



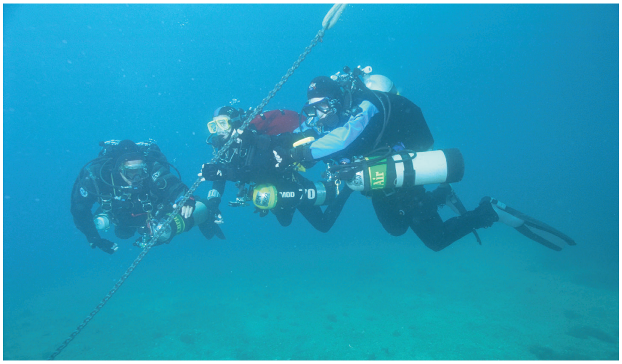
DSAT TecRec DIVE P

Gas	Planned Vol	w/Reserve(
Gas	Planned Vol	w/Reserve
Gas	Planned Vol	w/Reserve

Depth	Time	Runtime
45/150		
37/122 (ascent to deep stop)		
28.5/95 (deep stop)		
20/67 (ascent to 40 feet)		
12/40		
9/30		
6/20		
3/10		

Listing your ascent as midpoints between the bottom depth and the deep stop, and the deep stop and the first stop.

Some desk top deco software will automatically add deep stops if you want. If not, you must enter the deep stop as a way point in the profile it calculates. Don't make a deep stop unless it's in your schedule because, on a decompression model level, you're taking up nitrogen in slower compartments that you'll have to account for on shallower stops. Dive computers automatically account for this on deep stops when you make them.



Some desk top deco software will automatically add deep stops if you want. If not, you must enter the deep stop as a way point in the profile it calculates. Don't make a deep stop unless it's in your schedule because, on a decompression model level, you're taking up nitrogen in slower compartments that you'll have to account for on shallower stops.

Tec Exercise – 5.1

1. The oxygen-derived gradient that accelerates nitrogen diffusion out of your body is called the _________ _______.
2. The __________ _________ is what makes _________ _________ possible.
   - ☐ a. oxygen window, nitrogen uptake
   - ☐ b. oxygen window, accelerated decompression
   - ☐ c. nitrogen window, nitrogen uptake
   - ☐ d. nitrogen window, accelerated decompression
3. When decompressing with 100 percent oxygen, you can complete the decompression time for a 3 metre/10 foot stop as deep as 6 metres/20 feet without having to adjust your decompression time for the depth change because (check all that apply):
   - ☐ a. your EAD is always minus 10 metres/minus 33 feet,
   - ☐ b. there is no oxygen window above 6 metres/20 feet.
   - ☐ c. oxygen is more narcotic than nitrogen.
   - ☐ d. breathing pure oxygen, for practical purposes you lose nitrogen at the same rate regardless of depth.
4. To calculate an accelerated decompression dive (check all that apply):
   - ☐ a. you enter the gases you're using into desk top deco software and/or a multigas computer.
   - ☐ b. you use the EADs of each deco depth on a single gas table.
   - ☐ c. you must assume you'll only have one decompression gas.
   - ☐ d. None of the above.
5. To back up your deco information for an accelerated decompression dive, at the simplest, you can use desk top deco software to write alternative __________ ________ for doing your hang without your deco cylinders.
6. When choosing which gas blends to use for an accelerated decompression dive (check all that apply):
   - ☐ a. remember the KISS principle.
   - ☐ b. there may be little real benefit to taking one more gas blend.
   - ☐ c. you and your team mates need to choose compatible blends.
   - ☐ d. None of the above.
7. At its simplest, a deep stop is a stop made for ______ _______ at the _________ point between the bottom depth and the first _______ ______ _______.

Check it out:
1. oxygen window. 2.b. 3. a,d. 4. a. 5. emergency tables 6. a,b,c. 7. two minutes, halfway, required deco stop.

FIVE

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What are some of the procedures and considerations for making decompression dives in a current?
2. What is a "drift hang" and what are the advantages and disadvantages of it?

Techniques IV

Decompressing in Currents.

Much of what you've already learned and practiced involves diving in currents, making stops in them, and emergency procedures. These include using jon lines, lift bag procedures, descending and ascending along lines (boat, mooring, lift bag), carrying a drift kit, not staging cylinders if a current can keep you from returning to them, and using boat lines such as swim lines and trail lines like you use in recreational diving. Some of your training dives may have involved some current. From previous discussions you know that before making decompression dives in an area with currents, you should gain experience and be thoroughly familiar with the local techniques by making no stop dives first. It's easy to overexert yourself trying to out swim a current wearing just recreational equipment; in tec gear it's even easier. Use your brain, not your back, to work a current.

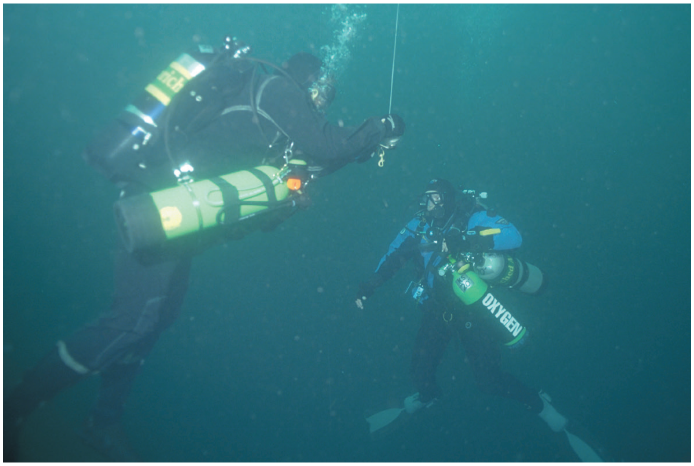
Drift Hangs. Decompressing in a current is a pain in the rump. Even using a jon line, it's often tiring, especially when you're in strong current and have a long hang. In some situations you don't have a choice, so you deal with it.

But often an alternative is a "drift hang" (also called "blue water decompression") in which divers decompress along a line from a float or boat while adrift in the current. The procedures vary, but in general:

1. All divers return to mooring/anchor line and start decompression maintaining place in current.
2. The boat lowers (or has in place) a weighted line.
3. On signal, support divers release the boat from the mooring/anchor, and all divers swim to weighted line while maintaining their stop depth.
4. Divers complete decompression on the weighted line.

There are variations, such as the breakaway hang. In this case, the team releases a line with a float ball from a mooring or other anchor point. Team decompresses drifting with the boat following the float ball. Essentially, decompressing under your lift bag, as either a planned primary procedure or as a back up procedure, is a variation of the breakaway hang.

Drift hangs have several advantages, the first being that once you're adrift, for all practical purposes there is no current. Everyone moves with the water, so it's much more restful. Another advantage is that it's easier to maintain your stop depth. And, if you have surface support they can more easily take your unneeded gear, or bring down extra gas, etc.



Drift hangs have several advantages, the first being that once you're adrift, for all practical purposes there is no current. Everyone moves with the water, so it's much more restful. Another advantage is that it's easier to maintain your stop depth.

Drift hangs do have some disadvantages. First, they require close coordination of all teams in the water. Second, is that typically, everyone must dive together — you often can't stagger teams coming out and going in (this isn't an absolute — in some areas, there are ways to do this, though this isn't typical). Another potential issue is that waiting for one diver can hold up the drift for several teams; procedures need to include actions for disoriented divers (usually requires sending up a bag and drifting under it) and accounting for them by surface support. You almost always have to have surface support, at least minimally. Finally, you need to account for how far and in which direction you'll drift so you don't get pushed into sea lanes (ship traffic hazard) or water too shallow to decompress in.

FIVE

Tec Exercise – 5.2

1. Before making decompression dives in an area with currents, you should gain experience and be thoroughly familiar with the _______ _______ by making _____ _____ dives first.

2. Disadvantages of a drift hang include (check all that apply):
   - ☐ a. that they need close coordination.
   - ☐ b. one diver can hold up the entire drift hang.
   - ☐ c. you almost always need surface support.
   - ☐ d. you have to beware of which way and how far you'll drift.

Check it out:
1 local techniques, no stop. 2. a,b,c,d.

Tec Objectives

Highlight or underline the answers to this question when you find them:

1. What is the priority and how do you respond to an unresponsive diver at depth during a decompression dive?

Emergencies V

As discussed earlier with respect to a diver who convulses underwater, an unresponsive diver at depth is one of the most serious emergencies you can face. Having required decompression makes a rescue complicated. As a technical diver, you accept the risk and responsibility that something could cause you to become unresponsive, and that decompression requirements and the distance from the surface may make it difficult or impossible to effect a rescue before you drown.

If a team mate becomes unresponsive, the priority is getting the victim to the surface (but remember the recommendation is to wait for a convulsing diver to finish the convulsion). Hold the regulator in if it is in and the victim is breathing. If you need to tow the victim underwater to an appropriate ascent area to make a rescue possible (due to current, proximity of surface support, etc.), make the victim neutrally buoyant and hold the mouthpiece in while towing.

As soon as possible, get the victim to surface. Take the diver up yourself if possible and if, based on your decompression situation, you judge the risk of DCS isn't excessive. As discussed earlier, the recommendation is to not drop the victim's weights until reaching the surface so that you don't put yourself at risk from an uncontrolled ascent. Try to maintain a neutral airway that allows expanding gas to escape from the diver's lungs.

Signal surface support divers if available. If you owe a lot of stop time, but other divers completing or almost complete with their decompression are present, they may be able to take over the rescue with minimal DCS risk.

Whether to risk DCS yourself is a difficult call, but one you may have to make. If you owe relatively little decompression, the victim is breathing and has the regulator in, and there's assistance at the surface, the probability of the victim surviving is high and the probability of severe DCS is low. If you have a lot of decompression due, the victim is unbreathing and unresponsive and has been for some time, and there's little or no surface support, the DCS risk is high and the probability of bringing the victim back low.

As you know from your PADI Rescue Diver course, there are no hard rules — you can only make the best decision you can given the circumstances. Remember that you shouldn't take *unreasonable* risks yourself to help the victim — if you're in trouble, you can't help anyone else.

Tec Exercise – 5.3

1. If a team mate becomes unresponsive, the priority is ______ ____ _______ _____ _________ ________.

Check it out:
1. getting the victim to the surface.

Thinking Like a Tec Diver V

The previous discussion made it clear that in tec diving as in recreational diving, you don't always have easy answers in an emergency. You have to make decisions, not only about how to help someone, but even *if* you will help someone — because you don't if it will put you at unacceptable risk. Professional rescuers sometimes call this "Better thee than me."

To the uninformed, "better thee than me" might sound uncaring or mercenary, but the reality is the opposite for both you and the victim: You can't help someone if you're in trouble, too. You can't even go get more help. When help does show up, two divers in trouble splits the emergency resources.

In team tec diving, a similar situation may arise in which a team mate enters a situation that poses an unacceptable risk for you. You may have to decide whether to accept the risk to help your team mate manage it, or whether to leave your team mate to manage solo. As a team member, you accept that you will take some risk (tec diving involves risk) for each other.

But, at the extreme it is better to have only one diver hurt or dead than two or three. Should you take the risk? As with the unresponsive diver, there are no hard rules, only hard decisions. You'll have to use good judgment and make the best decision you can under the circumstances.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. Professionals involved with rescue sometimes cite the philosophy, "Better thee than me." What does this mean and how does it apply to tec diving?
2. How do you plan for "specific" mistakes and emergencies?

Foreseeing the Foreseeable

Most of your training in the Tec Deep Diver course prepares you for common, reasonably foreseeable risks in deep tec diving to 50 metres/165 feet. But that's not all there is to it. Skilled tec divers learn to look at each dive and plan for reasonably foreseeable mistakes and emergencies specific to that dive.

This isn't that hard. For example, in poor visibility, you note that team separation is a foreseeable mistake and agree on what to do if it happens. In current, you realize that you may have to work harder, causing higher gas consumption that you have to prepare for. In cold water, you plan for the problems of working your gear with thick gloves and some narcosis. Diving in a new environment raises reasonably foreseeable issues. Haven't worn cold water gloves in awhile? Then maybe you should practice with them in the pool before making a tec dive in them. Been diving in cool water dry and now you're going to make a tropical tec dive in a wet suit? Then maybe you should gear up and get wet in a pool or controlled conditions in that configuration before making the tec jump.

Teach yourself to be specific to the dive when covering A Good Diver's Main Objective Is To Live. You do this by asking, as you already learned, "What about this can hurt or kill me?" Before you dive, have a way to handle every reasonable problem you come up with.

Tec Exercise – 5.4

1. The "better thee than me" philosophy considers that (check all that apply):
   - ☐ a. staying out of trouble yourself is best for the victim, too.
   - ☐ b. you may have to judge whether the risk of helping someone is acceptable.
   - ☐ c. you should take no risk at all for someone else.
   - ☐ d. you have to make the best decision you can under the circumstances.

2. Planning for "specific" mistakes and emergencies (check all that apply):
   - ☐ a. is handled by looking at possible mistakes and emergencies specific to each dive.
   - ☐ b. is not necessary because fundamental training covers it.
   - ☐ c. is really not practical.
   - ☐ d. is something that asking "What about this can hurt or kill me?" helps you do.

Check it out:
1. a,b,d. c is incorrect — you want to avoid unacceptable risk when helping someone, not necessarily all risk. 2. a,d.

Mission Planning

"Main" in A Good Diver's Main Objective Is To Live stands for "mission." This is your dive objective, which is usually more than simply going for a look. Without a mission, you're nothing more than an underwater gear manager — and that accomplishes *nothing*. You'll quickly find it unsatisfying. The whole point of learning to tec dive is so you can do something. Possible missions are limitless, but some examples are:

- Checking out new sites to see whether they're worth further exploration.
- Mapping (ships, caves, reefs)
- Recovering something.
- Photo/video.
- Taking samples/recording observations (science related)
- Evaluating equipment or procedure performance for future application.
- Team practice for a more complex dive.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. What is your dive "mission" and why do you have one?
2. Where does your dive mission "objective" rank in priority with the other aspects of a tec dive?
3. What is the most common mistake in mission planning?
4. How can you simplify a dive mission?
5. How does mission planning usually affect dive planning?

Your dive has a mission for two primary reasons: First, it helps assure that the dive is worth the time and money you put into it. Second, it coordinates the dive team's planning and dive execution by providing a common purpose. Those are pretty good reasons to have a mission — but guess what: the mission ranks *last* amid all other dive planning considerations. As you learned, everyone returning unharmed is the *first* priority on a tec dive. Or put another way, a good diver's main objective is to live. (That should sound familiar.)

Mission Planning

The most common mistake in mission planning, and the most common reason missions fail, is trying to accomplish *more than is reasonable in a single dive*. Since tec diving is itself complex, missions must be simple and realistic.

It's easy to recognize the need to simplify when the objective is obviously broad and complex, such as "map an entire shipwreck." For a major wreck, that's not a dive — that's not even a couple dives. It may be a dive *season* worth of dives.

The key to simplifying is analyzing the objective and determining the subtasks it involves. If there are few and they're simple, then maybe it's reasonable to accomplish in a single dive. On the other hand, you may find that each subtask is a project requiring its own dive, or a separate team.

The ones that trip you up are the ones that are more complex than they sound. "Locate and recover a flooded DPV abandoned at 50 metres/165 feet" may not sound complex at first. But it is.

Simplifying Your Mission. The key to simplifying is analyzing the objective and determining the subtasks it involves. If there are few and they're simple, then maybe it's reasonable to accomplish in a single dive. On the other hand, you may find that each subtask is a project requiring its own dive, or a separate team. For instance, bringing up the DPV might require 1) a search, 2) rigging the flooded DPV to lift and 3) actually bringing it up. That may be two dives.

After breaking into subtasks, you have to consider whether subtasks are simple enough. Subtasks may have subtasks. Simplify by planning subtasks as dive missions based on time and what a team can reasonably accomplish on a single dive. As appropriate, divide subtasks among team members, according to qualifications. Or, divide subtasks among different teams, or accomplish the objective by handling the subtasks as several missions on several dives. If you can, organize so that a team can leave in mid-task and resume (or have another team resume) where they left off.

Don't forget that another way to simplify the complex is to train for it. If you can't break a mission into separate subtasks, your team rehearses what it's going to do (perhaps in shallow water) until it's down pat.

Mission Planning Amid Dive Planning

You'll find that a clear mission usually simplifies dive planning because it determines depth, time and location. Your team has a focus, so it's easier to reach a consensus about logistics, emergency plans, etc.

At times, logistics and conditions will change the mission. For example, when recovering the DPV with two dive teams, you plan to have one team search and the second team recover. But on the day of the dive, you find the visibility half its usual clarity, meaning the search will be more difficult and time consuming than expected. You revise the mission so both teams go in for the search, with the recovery rescheduled for the next day.

Beware of Task Focus Instead of Dive Focus. Your/the team's attention should always be on the dive *first*, the mission second. The dive ends at the required turn time or turn pressure, no matter how close or far from accomplishing the mission. This can be frustrating if you're so close to finishing you mission that if you push into your reserve just a hair. . . . Don't. This is where discipline comes in. Your first priority is the dive plan, not the mission. A good diver's main objective is to live.

Tec Exercise – 5.5

1. You have a mission because without it, you're nothing more than an underwater _______ _______.
2. The mission ranks _____ amid all other dive planning considerations.
3. The most common mistake in mission planning is trying to accomplish _______ ______ ______ ______ in a single dive.
4. The key to simplifying is analyzing the objective and determining the _________ it involves.
5. A clear mission usually _________ dive planning.

Check it out:
1. gear manager. 2. last. 3. more than is reasonable. 4. subtasks. 5. simplifies

Performance Objective

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan and compare the decompression requirements, oxygen exposure and gas requirements for several possible ways to execute an accelerated decompression dive based on a dive profile to 50 metres/165 feet for 45 minutes.

Preview: Practical Application Five

This Practical Application gives you hands on experience calculating and comparing the practical and theoretical advantages and disadvantages of using differing gas combinations for the same accelerated decompression dive. You'll work with desk top deco software, or if it's unavailable, with tables derived for accelerated decompression dives.

You'll calculate several versions of a dive to 50 metres/165 feet for 45 minutes, assuming switches to the deco gases at the depth where the blend has a PO_2 of 1.6 ata (rounded to the next shallowest "normal" 2 metre/10 foot stop depth is acceptable).

You'll calculate and compare this dive made with:

- Air , EANx32 and EANx40
- EANx23, EANx32 and EANx40
- Air, EANx36 and EANx80
- EANx23, EANx36 and EANx80
- Air, EANx36 and oxygen
- EANx23, EANx36 and oxygen
- Air, EANx50 and oxygen
- EANx23, EANx50 and oxygen

Your instructor will have you provide a printed/written analysis of the decompression requirements, gas requirements based on your personal SAC rates, the CNS clock and OTUs for each scenario. Be prepared to discuss the trade offs and relative pros and cons of the different gas blend combinations when used for this dive. Your instructor will want to know:

- Which combination produced the shortest and longest dive times?
- Which gas seemed to be least useful, for this dive, in providing an advantage.
- Would you need more than one cylinder of the same gas in some of the profiles you calculate?
- Would you use so little of one gas that it hardly seems worth the

trouble to carry it? Does it help to change the ranges over which you use each deco gas (switch to higher oxygen gas shallower so you use a deeper deco gas longer).

- Which combination would you choose in cold water?
- Is there a significant oxygen exposure advantage? What if you were making several dives like this over several days in a row?
- Is there a cost advantage, such as using air instead of EANx23 with little increase in deco time?

Performance Objective

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan Training Dives Eight and Nine following the A Good Diver's Main Objective Is To Live procedure, including mission planning in Dive Nine, based on the dive specifics (depths, environment, etc.) and mission provided by the instructor.

Preview: Practical Application Six

During this practical application, you'll work in teams to plan Training Dives Eight and Nine based on information your instructor provides. Consider A Good Diver's Main Objective Is To Live and refer back to this manual as you plan. Dive Eight will be a simulated accelerated decompression dive based on depth and time your instructor will provide (you actually make the dive within the no stop limits).

Dive Nine will be your first actual decompression dive, made based on using a single gas table/computer, with a single decompression gas as a pad for conservatism. You should plan the dive requiring only a single stop at 3 metres/10 feet or 5 metres/15 feet. If it will be a repetitive dive to Dive Eight, you'll need to account for residual nitrogen and oxygen exposure. (OTUs may be a factor for both dives if you've been diving for several days in a row.)

Dive Nine will also have a mission component that your instructor will assign. Your dive plan should include how you will attempt to accomplish this mission. Note: Since the mission is your last priority, you do not necessarily have to complete the mission. If you're unable to complete the task, your instructor will consider how effective you and your team were amid the other dive requirements. Accomplishing as much as would be reasonably possible without violating safety guidelines or the dive plan is what your instructor will be interested in. When working on this mission and future missions, pay attention to narcosis; this is an opportunity to learn how narcosis can affect you, even if you don't "feel narked."

Your instructor will provide the basis for determining your deco schedule and have you calculate, OTUs and CNS for each diver and gas, plus gas requirements including one-third reserve, tank base lines, turn points, equipment requirements, logistics, emergency procedures and other information from the A Good Diver's Main Objective Is To Live planning process.

Your written plans should contain all information you would need to make the dives.

Preview: Training Dive Eight

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan and execute a simulated accelerated decompression dive following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Tow a simulated unresponsive, breathing diver 6 metres/20 feet horizontally underwater.
3. Perform the gas shutdown drill on the bottom in 45 seconds.
4. Decompress following the schedule for a simulated accelerated decompression dive, making appropriate NO TOX gas switches as necessary to follow the schedule.
5. As a team, respond properly to a failed lift bag/lift bag line by maintaining stop depth while deploying a second bag, and completing the simulated decompression.
6. Perform the gas shutdown drill while neutrally buoyant at the stop depth while not varying more than one metre/three feet from the stop depth.
7. Demonstrate time, depth and gas supply awareness by recording the depth and time on a slate upon reaching a back gas pressure assigned by the instructor.

Predive briefing and gearing up

Training Dive Eight

- Record depth and time reading upon reaching an instructor-specified back gas pressure.

  Entry — appropriate for environment

  Weight check (if needed)

  Bubble check

  Don stage/deco cylinders at surface

  Descent

  Descent check

  Stage deco cylinders

  Unresponsive diver tow at depth — 6 metres/20 feet

  Gas shutdown drill — 45 seconds

  Retrieve and don deco cylinders

  Free time as bottom time and gas allows

  Deploy lift bag — ascent, NO TOX switch and begin simulated accelerated decompression

  Failed bag drill

  Continue decompression — air breaks

  Gas shutdown drill while neutrally buoyant

  Surface — remove stage/deco cylinders at surface

  Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Preview: Training Dive Nine

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan and execute a decompression dive based on a single gas table or computer with an enriched air blend for added conservatism following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Working in a team execute the dive's mission, carrying it out to the team's ability within the limits of the dive plan.
3. Demonstrate time, depth and gas supply awareness by recording the depth and time upon reaching an SPG reading assigned by the instructor, and by recording the depth and SPG reading upon reaching a bottom time assigned by the instructor.
4. Perform a timed task at the surface, and then again at depth, to observe the effect of narcosis.

Predive briefing, timed task at surface, and gearing up

Training Dive Nine

- Record depth and time reading upon reaching an instructor-specified back gas pressure, and record depth and SPG reading upon reaching a bottom time assigned by the instructor.

Entry — appropriate for environment

Weight check (if needed)

Bubble check

Don stage/deco cylinder at surface

Descent

Descent check

Stage deco cylinder at deco level (if appropriate)

Gas shutdown drill

Mission objective — timed task

Deploy lift bag — ascent, NO TOX switch and begin simulated accelerated decompression

Ascend, retrieve deco cylinder (if staged) and decompress with NO TOX switch at 5 metres/15 feet or 3 metres/10 feet — air breaks.

Surface — remove stage/deco cylinder at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

KNOWLEDGE Review – Chapter Five

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. Explain what the "oxygen window" is and how it relates to decompression. Why is it that when decompressing with 100 percent oxygen, you can complete the decompression time for a 3 metre/10 foot stop as deep as 6 metres/20 feet without having to adjust your decompression time for the depth change?

2. What's a "deep stop"? What's the benefit and how do you incorporate them into your dive schedule?

3. What are some of the procedures and considerations for making decompression dives in currents?

4. What is a "drift hang" and what are the advantages and disadvantages of it?

FIVE

5. What is the priority and how do you respond to an unresponsive diver at depth during a decompression dive?

6. Professionals involved with rescue sometimes cite the philosophy, “Better thee than me.” What does this mean and how does it apply to tec diving?

7. How do you plan for “specific” mistakes and emergencies?

8. What is the most common mistake in mission planning? Where does mission planning rank with the other aspects of a tec dive?

9. For a presentation that you're giving to local biologists on invertebrate populations on a local reef that's about two kilometres/a mile long, you're interested in estimating the number of sea stars per square metre/yard at depths between 30 metres/100 feet and 42 metres/140 feet. Your team plans to get this number; what subtasks might this mission entail? Would it be reasonable to do this in a single dive? How many dives might it take assuming a single team of three divers?

Student Diver statement: I've reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date __________

FIVE

Decompression in any form, was, is, and will always be, a necessary pain in the [rear end].

Bob Barth, The Sea Dwellers, 1999
US Navy Diver, Aquanaut,
Sealabs I, II & III

Chapter SIX: The Polish

Chapter Six — last but not least. Well, it is least in that it's the shortest. Chapter Six puts the final polish on the knowledge you've been developing and applying in this course. You start with *emergencies* and a detailed review of decompression illness and its first aid. Then, *thinking* like a tec *diver* goes into some final thoughts and advice for you, the soon-to-be Tec Deep Diver.

And that's it. After you master the Tec Objectives in this chapter, you should be ready for the final two practical applications (including the second exam), and for your final three training dives.

Emergencies VI

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. How do you define decompression sickness, arterial gas embolism and decompression illness?
2. What are the signs and symptoms of decompression illness?
3. What is the first aid for suspected decompression illness?
4. How does administering oxygen benefit a patient with decompression illness?
5. How do you administer a field neurological exam?
6. How can having diver accident insurance make treatment for decompression illness more effective?

If there's anything you've picked up in this course, it's that technical divers face risks that recreational divers don't, and face some of the same risks to a greater degree. One of the latter is decompression illness (DCI). This is an issue important enough that it's worth reviewing what you've already learned about DCI.

As you learned in the PADI Rescue Diver course, *arterial gas embolism* (AGE) is the condition in which air bubbles enter the bloodstream through a lung rupture, usually the result of holding the breath during ascent. *Decompression* sickness (DCS) is the condition in which inert gas (nitrogen) forms bubbles in the tissues and bloodstream as it comes out of solution due to high supersaturation following ascent.

Decompression illness is the field term for both DCS and AGE together. The first aid and emergency management for both is identical, so it's not important — and sometimes impossible — to distinguish between DCS and AGE. In a first aid situation, you only need think about the one, broader condition — DCI.

Signs and symptoms of DCI include pain in the joints or mid limb, undue fatigue, inability to urinate, blurred vision, blotchy skin rash, tingling in the extremities, swelling, vertigo, hearing or speech impairment, paralysis, numbness, unconsciousness, bloody froth from the mouth, loss of coordination, personality change and respiratory/cardiac arrest. The symptoms can be immediate (usually when AGE related), or delayed (when DCS related).

First Aid for DCI

At this writing, the recommendations for DCI first aid are as follows, but it's your responsibility to keep up with the latest findings on DCI first aid, and follow the most up to date protocols. It's also your responsibility to include preparing to handle DCI in dive planning, including both first aid and steps for getting a patient into emergency medical care.

- Keep the patient lying down; on the back is fine for a responsive patient, left side down (recovery position) is the position to use for an unresponsive breathing patient.

- Monitor airway, breathing and circulation (ABCs) and administer CPR as necessary.
- Administer emergency oxygen to a breathing patient, ideally 100 percent via a demand system.

  A very weak patient may not be able to breathe with a demand system — use freeflow oxygen with a nonrebreather mask and reservoir bag set at 15 litres per minute flow rate. Remember to inflate the bag before placing the mask on the patient's face; if the bag deflates completely when the patient inhales, set the flow at 25 litres per minute.

The primary first aid for suspected DCI is to administer emergency oxygen to a breathing patient, ideally 100 percent via a demand system.

  For a nonbreathing patient, use freeflow oxygen while providing rescue breaths through a pocket mask. If the patient resumes breathing, switch to the demand or nonrebreather mask.

  Continue oxygen until you get the patient into emergency medical care, or until you run out. Monitor the oxygen pressure gauge; don't let the cylinder run empty with the mask still on the patient. If you run out of oxygen, as a tec diver you may have EANx80 or other high oxygen blend to use if the patient can breathe through a standard regulator.

A very weak patient may not be able to breathe with a demand system — use freeflow oxygen with a nonrebreather mask and reservoir bag set at 15 litres per minute flow rate.

  You may give a fully responsive patient fluids to help maintain hydration. Keep the patient lying down, with water the preferred fluid. Isotonic fluids and fruit juices are acceptable; avoid anything with caffeine or alcohol.

- Contact emergency medical care and the diver emergency service (DAN, DES) that serves the area and get the patient into emergency medical care, and ultimately to a recompression facility as guided by the diver emergency service and the local medical system. Statistics show that the sooner recompression treatment begins, the more probable is complete resolution of symptoms. Delays, on the other hand, are more prone to leave permanent or extended residual symptoms.

For a nonbreathing patient, use freeflow oxygen while providing rescue breaths through a pocket mask.

The Importance of Oxygen

After all you've learned about oxygen's role in decompression, it's logical that it can play a big part in managing DCI. Oxygen administration has proved to reduce DCI symptom severity and improve the probability of a successful treatment. Sometimes, symptoms disappear entirely while the patient is on oxygen (though it doesn't usually replace recompression therapy).

Once DCI manifests itself, breathing pure oxygen helps oxygenate tissues suffering from restricted blood flow due to bubble formation. This helps protect these tissues until the patient receives recompression, and is a benefit that has little relationship to the benefits of breathing oxygen while decompressing.

On the other hand, just as it does in decompression, the oxygen window speeds dissolved nitrogen out of the body faster, minimizing and slowing further bubble growth to reduce further and worsening symptoms. The longer you keep the oxygen window open, the better.

Plan your emergency oxygen supply based on how long it would take to get a diver into emergency medical care. You can extend your oxygen supply by adding a rebreather emergency oxygen unit to your emergency oxygen kit. This unit recycles unused oxygen and greatly expands how long your supply lasts, though it takes a little bit of additional training to use.

You can extend your oxygen supply by adding a rebreather emergency oxygen unit to your emergency oxygen kit. This unit recycles unused oxygen and greatly expands how long your supply lasts, though it takes a little bit of additional training to use.

Field Neurological Examination

DCI symptoms and signs can be ambiguous. If unsure whether symptoms suggest DCI, you can use a field neurological exam to look for possible effects on the nervous system. If you find any irregularities, assume DCI, begin first aid and contact emergency medical care.

To perform a field neurological exam:

1. Have the patient follow your finger with both eyes. They should track together.
2. Have the patient use both hands to squeeze yours. Weakness on one side suggests a problem.
3. Ask the patient to close both eyes, stretch out the arms and then bend at the elbows to touch the nose with fingertips. The inability to do this with both or either hand suggests a problem.
4. The patient should be able to stand on one foot.
5. Snap your fingers on either side of the patient's head. Ask if there's any significant difference in loudness. A significant difference can suggest nerve damage, though with this test ear squeeze or water in the ear canal could be at fault. Obviously, a field examination by a lay rescuer isn't intended to replace diagnosis by emergency medical professionals.

The Role of Diver Accident Insurance

Besides emergency oxygen and recompression, one of the best tools for a more effective DCI treatment is diver accident insurance. At first it might not seem that helping pay for treatment should make the treatment any better, *but it can.*

Because the more quickly a patient begins treatment the more likely a favorable outcome, you want to minimize anything that would delay treatment should you ever need it — especially as a tec diver. Delays sometimes result from questions about payment for a recompression treatment, especially because most conventional medical policies do not cover recompression. Diver accident insurance minimizes these delays by establishing the financial coverage. This is why some dive charter boats and dive sites, especially those catering to tec divers, require diver accident insurance.

Therefore, carrying diver accident insurance that covers tec diving (be sure it's stipulated in the coverage you get) such as offered by PADI and DAN, reduces or eliminates recompression delays that would stem from financial concerns. Compared to your overall investment in tec diving, diver accident insurance costs very little, yet can potentially benefit treatment outcome and the financial picture if you should experience DCI.

The truth is, given the higher risks you face as a tec diver, you're not being very responsible if you don't carry diver accident insurance coverage.

Tec Exercise – 6.1

1. Decompression illness (check all that apply):
   - ☐ a. may be caused by inert nitrogen coming out of solution in the tissues.
   - ☐ b. may be caused by air entering the bloodstream through a lung rupture.
   - ☐ c. exactly the same thing as DCS.
   - ☐ d. is a term used in the field for both DCS and AGE.
2. Signs and symptoms of DCI include (check all that apply):
   - ☐ a. pain in the joints/mid limb
   - ☐ b. paralysis
   - ☐ c. unconsciousness
   - ☐ d. undue fatigue
3. The first aid for a suspected DCI patient includes (check all that apply):
   - ☐ a. 100 percent oxygen.
   - ☐ b. keep the patient seated.
   - ☐ c. CPR and rescue breathing as needed.
   - ☐ d. contact emergency medical care and the local diver emergency service.
4. Administering oxygen benefits a patient by oxygenating tissues with restricted blood flow, and by helping speed dissolved nitrogen out of the tissues.
   ☐ True ☐ False
5. Steps in administering a field neurological exam include (check all that apply):
   - ☐ a. having the patient follow your finger with both eyes.
   - ☐ b. having the patient squeeze your hands.
   - ☐ c. having the patient listen for your fingers to snap on either side of the head.
   - ☐ d. having the patient jump up and down on one foot with the eyes closed.
6. Diver accident insurance benefits recompression treatment by allowing you to afford therapies that are expensive and considered optional.
   ☐ True ☐ False.

Check it out:
1. a,b,d. 2.a,b,c,d. 3. a,c,d. b is incorrect because the patient should be kept lying down. 4. True. 5. a,b,c. 6. False. Diver accident insurance benefits recompression by reducing delays associated with questions about payment.

Tec Objectives

Highlight or underline the answers to these questions as you find them:

1. How do prudent tec divers broaden their abilities and limits within tec diving?
2. What quality do you find in tec divers who extend their personal limits at an appropriate pace?

Thinking Like a Tec Diver VI

The Tec Deep Diver course qualifies you to enter the initial ranks of deep tec diving. Hopefully, the one thing you've learned as you've gone through your training is that there's quite a difference between knowing what a tec dive requires and doing the dive. The difference lies in the gap between theory and practice, between going through the steps to a procedure for a first run, and enacting the same procedure automatically when you or a team mate's life depends on it. You only get where you need to be through practice and experience.

Consider that when astronauts and cosmonauts train, they may train for three or four years for a single mission. They practice the procedures for every conceivable emergency, ranging from minor equipment failure to having their space craft begin to disintegrate around them as they launch. Many of the procedures are simple to describe — but not so simple to apply amid a thousand other tasks they have to manage. Space travel makes it clear that knowing and doing are two things, and the training has to reflect that. No one goes into space until entirely trained and qualified. The stakes are way too high.

(Photo courtesy of NASA)

Astronauts and cosmonauts, and tec divers face similar challenges, albeit on different complexity scales. Both enter an extreme environment where humans cannot live without life support. Both do so in a manner in which they depend utterly on that life support. Both go where there's no rescue possible.

"Sure, but that's for space," you might say, "Tec diving doesn't take all that."

Astronauts and cosmonauts do train for a more demanding environment using far more complex technology, but they and tec divers face similar challenges, albeit on different complexity scales. Both enter an extreme environment where humans cannot live without life support. Both do so in a manner in which they depend utterly on that life support. Both go where there's no rescue possible (most of the time, anyway).

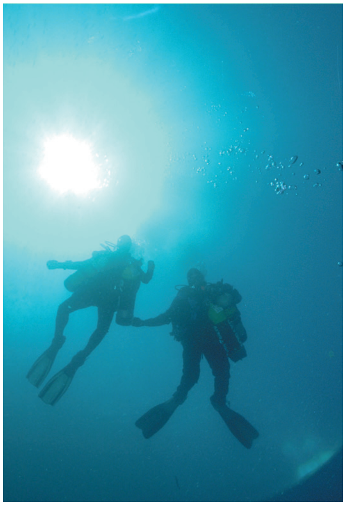
The quantity of knowledge and number of skills needed for space travel far surpasses tec diving, but the required mastery level and the psychological stresses are surprisingly similar. And, an astronaut crew has an advantage over a tec dive team — when there's a problem, the crew has more than a thousand experts from every field on the ground standing by to create a solution and talk them through it. When you face a problem in tec diving, your team faces it alone. With these similarities, it should be no surprise to learn that the Tec Deep Diver course and astronaut/cosmonaut training have parallels, and in fact in many ways this course draws directly upon what the US National Aeronautics and Space Administration (NASA) has learned in almost four decades of training humans for space flight.

What's the point of all this? Simple: Even before they finish the course, it's not unusual for many divers entering tec diving to be thinking ahead to their next course and extending beyond the limits this course qualifies them for. But getting ahead of yourself in tec diving is the recipe for getting hurt or killed — you may know the theories, you may be able to explain an emergency procedure, but in tec diving as in space travel, there's often a huge gap between knowing and doing.

Here's how prudent tec divers (which includes you, right?) expand their abilities:

Gain Experience. The most important immediate step is to gain experience within your current qualifications. Experience now forms the foundation you need to build on to go forward. The Tec Deep Diver course develops skills that you'll need to enact innately during more complex dives. Dive, dive, dive and make these skills as routine as your recreational dive skills are.

Push Your Comfort Zone *Gently*. It's acceptable to extend your limits a bit as you gain experience — if it weren't, there would be no way to grow. Prudent tec divers extend themselves carefully, only slightly beyond their experience, and are always prepared to pull back.



Keep in mind that the top names and leaders in tec diving, almost as a rule, reached their current status over a period of years and hundreds of dives and by sharing a common quality: patience.

Learn From Those With Experience. Hang out with and dive with experienced tec divers, especially teams. You'll learn a lot and get a lot of guidance. Although you typically start as a support diver, as you prove your mettle, gain experience and broaden your qualifications, you'll find yourself on increasingly exciting dives.

Respect the Limits. Although you're extending your limits, you've been taught the outside limits to your qualifications. Respect these. They're the line between where experience ends and training has to pick up for you to move on without unreasonable risk.

Continue Training. In some types of tec diving, such as cave diving or inside wrecks, learning by experience is extremely hazardous. The way to move past the outside limits to your qualifications, once you've gained experience, is to train for a new set of limits and gain experience with them. Yes, before there was training others had to go through the limits without it, but that's done. No need to repeat their mistakes (some of which killed people).

Keep in mind that the top names and leaders in tec diving, almost as a rule, reached their current status over a period of years and hundreds of dives. Some grew faster than others, depending on their aptitude and the state of the art at the time, but they came to the forefront of tec diving by sharing a common quality: patience. They didn't move on before they were prepared and qualified. To be blunt, if you don't have patience, you don't belong in tec diving.

If you do, best of success to you and the teams you work with.

Tec Exercise – 6.1

1. Prudent tec divers expand their limits by (check all that apply):
   - ☐ a. gaining experience.
   - ☐ b. pushing their comfort zone gently.
   - ☐ c. learning from those with experience.
   - ☐ d. respecting the limits of their training.

2. The quality tec divers who extend their limits prudent share is ___________.

Check it out:
1. a,b,c,d. 2. patience.

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan Training Dives Ten and Eleven following the A Good Diver's Main Objective Is To Live procedure, including mission planning, based on the dive specifics (depths, environment, etc.) and mission provided by the instructor.

Preview: Practical Application Seven

During this practical application, you'll work in teams to plan Training Dives Ten and Eleven based on information your instructor provides. By now, complete dive planning should be becoming routine for you. Consider A Good Diver's Main Objective Is To Live and refer back to this manual as you plan. Dive Ten is a decompression dive based on a single gas table/computer, with at least two decompression stops using enriched air and/or oxygen to make the decompression more conservative. Dive Eleven is an accelerated decompression dive with at least two decompression stops.

Both dives will also have a mission component that your instructor will assign. Your dive plan should include how you will attempt to accomplish this mission. Note: As before, since the mission is your last priority, you do not necessarily have to complete the mission. If you're unable to complete the task, your instructor will consider how effective you and your team were amid the other dive requirements. Accomplishing as much as would be reasonably possible without violating safety guidelines or the dive plan is what your instructor will be interested in.

Your instructor will provide the basis for determining your deco schedule and have you calculate, OTUs and CNS for each diver and gas, plus gas requirements including one-third reserve, tank base lines, turn points, equipment requirements, logistics, emergency procedures and other information from the A Good Diver's Main Objective Is To Live planning process.

Your written plans should contain all information you would need to make the dives.

Preview: Training Dive Ten

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan and execute a decompression dive based on a single gas table or computer with an enriched air blend for added conservatism following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Working in a team execute the dive's mission, carrying it out to the team's ability within the limits of the dive plan.

Predive briefing and gearing up

Training Dive Ten

Entry — appropriate for environment

Weight check (if needed)

Bubble check

Don stage/deco cylinders at surface

Descent

Descent check

Mission

Ascent — NO TOX switches and decompression — air breaks

Surface — remove stage/deco cylinders at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Preview: Training Dive Eleven

Training Dive Eleven

Entry — appropriate for environment

Weight check (if needed)

Bubble check

Don stage/deco cylinders at surface

Descent

Descent check

Mission

Ascent — NO TOX switches and decompression — air breaks

Surface — remove stage/deco cylinders at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan and execute an accelerated decompression dive based on table and/or multigas computer following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Working in a team execute the dive's mission, carrying it out to the team's ability within the limits of the dive plan.

Performance Objectives

To successfully complete this Practical Application, you will be able to:

1. Working as a team, plan Training Dive Twelve following the A Good Diver's Main Objective Is To Live procedure, including mission planning, based on the dive specifics (depths, environment, etc.) and mission provided by the instructor.

Preview: Practical Application Eight

During this practical application, you'll work in teams to plan Training Dive Twelve based on information your instructor provides. Dive planning should be becoming routine for you. Your written plan should contain all information you would need to make the dive.

You will also complete Exam Two. As with Exam One, this is not a team exercise. You may use a calculator, and refer to the tables in the appendix of this manual, but no other section. As with Exam One, you'll be required to hand in your scatch paper. You must earn 80 percent or better on both sections to be successful.

Preview: Training Dive Twelve

Performance Objectives

To successfully complete this training dive, you will be able to:

1. Working in a team, plan and execute a two or more stop decompression dive based on table and/or a computer following the A Good Diver's Main Objective Is To Live procedure, and perform predive checks following the Being Wary Reduces All Failures procedure, the bubble checks and descent checks.
2. Working in a team execute the dive's mission, carrying it out to the team's ability within the limits of the dive plan.

Training Dive Twelve

Entry — appropriate for environment

Weight check (if needed)

Bubble check

Don stage/deco cylinders at surface

Descent

Descent check

Mission

Ascent — NO TOX switches and decompression — air breaks

Surface — remove stage/deco cylinders at surface

Exit

Post Dive

Performance review

Disassemble and stow equipment

Log dive for instructor signature.

KNOWLEDGE Review – Chapter Six

Please complete this review, and remove it from the manual to hand in to your instructor. If there's something you don't understand, review the related material. If you still don't understand, be sure to have your instructor explain it to you.

1. Define decompression sickness, arterial gas embolism and decompression illness:

2. List the signs and symptoms of decompression illness.

3. Explain the procedure for first aid for suspected decompression illness.

4. Explain how to administer a field neurological exam.

SIX

5. Explain how having diver accident insurance can make treatment for decompression illness more effective.

6. List the steps you will take as a prudent tec diver to broaden your abilities and limits within tec diving.

7. What quality should you have to extend your personal limits at an appropriate pace?

Student Diver statement: I've reviewed the questions I answered incorrectly or incompletely, and I now understand what I missed.

Signature____Date __________

APPENDIX

260 Key Formulas

264 CNS Surface Interval Credit Table

264 Oxygen Exposure Limits

265 SAC Conversion Factors

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295 Tec Deep Diver Statement of Understanding and Learning Agreement

Key Formulas

Equivalent Air Depth (EAD) Formula

METRIC

$$EAD = \frac{(1\text{-fraction of oxygen}) \times (\text{Depth in metres}+10)}{.79} - 10$$

IMPERIAL

$$EAD = \frac{(1\text{-fraction of oxygen}) \times (\text{Depth in feet}+33)}{.79} - 33$$

Maximum Depth Formulas

METRIC

$$\text{Bottom max depth (1.4 ata)} = \left(\frac{14}{\text{fraction of oxygen}}\right) - 10$$

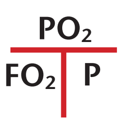
$$\text{Deco max depth (1.6 ata)} = \left(\frac{16}{\text{fraction of oxygen}}\right) - 10$$

IMPERIAL

$$\text{Bottom max depth (1.4 ata)} = \left(\frac{46.2}{\text{fraction of oxygen}}\right) - 33$$

$$\text{Deco max depth (1.6 ata)} = \left(\frac{52.8}{\text{fraction of oxygen}}\right) - 33$$

The T Formula



Where:

PO_2 = partial pressure of oxygen in ata

FO_2 = the fraction of oxygen in the blend

and P = absolute pressure in ata

Finding Your Surface Air Consumption (SAC) Rate Formula

METRIC

$$\text{litres per minute SAC} = \frac{\text{bar used x total cylinder capacity litres}}{(\text{depth in metres} + 10) \div 10} \div \text{min}$$

Example: You use 25 bar with twin 12 litre cylinders (total 24 litres capacity) while swimming at 15 metres for 10 minutes.

$$\frac{25 \text{ x } 24}{(15 + 10) \div 10} \div 10 = \frac{600}{2.5} \div 10 = 24 \text{ litres per minute SAC rate}$$

IMPERIAL

$$\text{cf per min SAC} = \frac{(\text{psi used} \div \text{working pressure}) \text{ x total cylinder capacity}}{(\text{depth in feet} + 33) \div 33} \div \text{min}$$

Example: You use 370 psi with twin 71 cubic foot cylinders (142 total capacity, working pressure 2475 psi) while swimming at 50 feet for 10 minutes.

$$\frac{(370 \div 2475) \text{ x } 142}{(50 + 33) \div 33} \div 10 = \frac{21.2}{2.5} \div 10 = .84 \text{ cubic feet per minute SAC rate}$$

Gas Requirement Estimate Formulas

METRIC

litres required
= (min x SAC rate) x ((depth in metres + 10) ÷ 10)

Example: If your SAC rate is 22 litres per minute, how much gas supply do you need for 15 minutes at 33 metres?

litres required = (15 x 22) x ((33 + 10) ÷ 10)

litres required = 330 x 4.3

litres required = 1419

IMPERIAL

cubic feet required
= (min x SAC rate) x ((depth in feet + 33) ÷ 33)

Example: If your SAC rate is .77 cubic feet per minute, how much gas supply do you need for 15 minutes at 110 feet?

cubic feet required = (15 x .77) x ((110 + 33) ÷ 33)

cubic feet required = 11.6 x 4.3

cubic feet required = 49.9

Gas Reserve Formula

$$\frac{\text{gas volume required}}{(1 - \text{reserve})} = \text{total gas}$$

METRIC

For example: If you estimate you need 1419 litres of a gas, what's your gas requirement with a 33 percent reserve?

$$\frac{1419}{(1 - .33)} = \frac{1419}{.66} = 2150 \text{ litres}$$

IMPERIAL

For example: If you estimate you need 49.9 cubic feet of a gas, what's your gas requirement with a 33 percent reserve?

$$\frac{49.9}{(1 - .33)} = \frac{49.9}{.66} = 75.6 \text{ cubic feet}$$

Rule of Thirds "Shortcut" Formula

gas volume required x 1.5 = total gas

Actual Gas Supply Formulas

METRIC

designated volume in litres x pressure in bar = available volume in litres

IMPERIAL

actual pressure in psi ÷ working pressure in psi x capacity in cubic feet = available volume in cubic feet

Actual Gas Supply, Imperial Baseline Method

capacity in cubic feet ÷ working pressure in psi = baseline

baseline x actual pressure in psi = available volume in cubic feet

Ascent Depth Formula

ascent depth = ((bottom depth - first stop depth) ÷ 2) + first stop depth

Ascent Time To First Stop Forumla

ascent time = (bottom depth - first stop depth) ÷ ascent rate

Gas Requirement Estimate Using Conversion Factor Formula

gas required = SAC x minutes x conversion factor

Back Gas Turn Pressure Formula

METRIC

turn pressure = start pressure - (bottom volume ÷ cylinder capacity)

IMPERIAL

turn pressure = start pressure - (bottom volume ÷ cylinder baseline)

Gas Matching Formulas

METRIC

small supply reserve pressure = (large supply volume ÷ 3) ÷ small supply cylinder capacity

small supply turn pressure = small supply actual pressure - ((small supply actual pressure - small supply reserve pressure) ÷ 2)

IMPERIAL

small supply reserve pressure = (large supply volume ÷ 3) ÷ small supply cylinder baseline

small supply turn pressure = small supply actual pressure - ((small supply actual pressure - small supply reserve pressure) ÷ 2)

CNS SURFACE INTERVAL CREDIT TABLE

Starting CNS%	0:00 – 0:30	0:31 – 1:00	1:01 – 1:30	1:31 – 2:00	2:01 – 3:00	3:01 – 4:00	4:01 – 6:00	6:01 – 9:00
10%	10%	8%	6%	5%	4%	3%	2%	1%
20%	20%	16%	13%	10%	8%	5%	3%	1%
30%	30%	24%	19%	15%	12%	8%	5%	2%
40%	40%	32%	25%	20%	16%	10%	6%	2%
50%	50%	40%	32%	25%	20%	13%	8%	3%
55%	55%	44%	35%	28%	22%	14%	9%	3%
60%	60%	48%	38%	30%	24%	15%	10%	4%
65%	65%	52%	41%	33%	26%	16%	10%	4%
70%	70%	56%	44%	35%	28%	18%	11%	4%
75%	75%	60%	47%	38%	30%	19%	12%	5%
80%	80%	64%	50%	40%	32%	20%	13%	5%
85%	85%	68%	54%	43%	34%	21%	14%	5%
90%	90%	72%	57%	45%	36%	23%	14%	5%
95%	95%	76%	60%	48%	38%	24%	15%	6%
100%	100%	80%	63%	50%	40%	25%	16%	6%

OXYGEN EXPOSURE LIMITS

NOAA Oxygen Exposure Limits

PO_2	Single Exposure	Total in 24 Hours
0.6	720	720
0.7	570	570
0.8	450	450
0.9	360	360
1	300	300
1.1	240	270
1.2	210	240
1.3	180	210
1.4	150	180
1.5	120	180
1.6	45	150

Oxygen Tolerance Units Exposure Limits

Days	Total OTUs for Mission	Average OTUs Per Day
1	850	850
2	1400	700
3	1860	620
4	2100	525
5	2300	460
6	2520	420
7	2660	380
8	2800	350
9	2970	330
10	3100	310
11	3300	300
12	3600	300
13	3900	300
14	4200	300
15-30	as required	300

SAC CONVERSION FACTORS

Multiply your SAC rate by the factor to determine your gas comsumption rate at depth.

Metric

Depth (m)	Conversion Factor
3	1.3
5	1.5
6	1.6
9	1.9
12	2.2
15	2.5
18	2.8
21	3.1
24	3.4
27	3.7
30	4.0
33	4.3
36	4.6
39	4.9
42	5.2
45	5.5
48	5.8
50	6.0
54	6.4
57	6.7

Imperial

Depth (ft)	Conversion Factor
10	1.3
15	1.5
20	1.6
30	1.9
40	2.2
50	2.5
60	2.8
70	3.1
80	3.4
90	3.7
100	4.0
110	4.3
120	4.6
130	4.9
140	5.2
150	5.5
160	5.8
165	6.0
170	6.2
180	6.5

MAXIMUM DEPTHS IN FEET OF SEAWATER

BLEND	@1.4	@1.6
21%	187	218
22%	177	207
23%	168	197
24%	160	187
25%	152	178
26%	145	170
27%	138	163
28%	132	156
29%	126	149
30%	121	143
31%	116	137
32%	111	132
33%	107	127
34%	103	122
35%	99	118
36%	95	114
37%	92	110
38%	89	106
39%	85	102
40%	83	99
41%	80	96
42%	77	93
43%	74	90
44%	72	87
45%	70	84
46%	67	82
47%	65	79
48%	63	77
49%	61	75
50%	59	73
51%	58	71
52%	56	69
53%	54	67
54%	53	65
55%	51	63
56%	49	61
57%	48	60
58%	47	58
59%	45	56

BLEND	@1.4	@1.6
60%	44	55
61%	43	54
62%	42	52
63%	40	51
64%	39	50
65%	38	48
66%	37	47
67%	36	46
68%	35	45
69%	34	44
70%	33	42
71%	32	41
72%	31	40
73%	30	39
74%	29	38
75%	29	37
76%	28	36
77%	27	36
78%	26	35
79%	25	34
80%	25	33
81%	24	32
82%	23	31
83%	23	31
84%	22	30
85%	21	29
86%	21	28
87%	20	28
88%	20	27
89%	19	26
90%	18	26
91%	18	25
92%	17	24
93%	17	24
94%	16	23
95%	16	23
96%	15	22
97%	15	21
98%	14	21
99%	14	20
100%	13	20

MAXIMUM DEPTHS IN METRES OF SEAWATER

BLEND	@1.4	@1.6
21%	57	66
22%	54	63
23%	51	60
24%	48	57
25%	46	54
26%	44	52
27%	42	49
28%	40	47
29%	38	45
30%	37	43
31%	35	42
32%	34	40
33%	32	38
34%	31	37
35%	30	36
36%	29	34
37%	28	33
38%	27	32
39%	26	31
40%	25	30
41%	24	29
42%	23	28
43%	23	27
44%	22	26
45%	21	26
46%	20	25
47%	20	24
48%	19	23
49%	19	23
50%	18	22
51%	17	21
52%	17	21
53%	16	20
54%	16	20
55%	15	19
56%	15	19
57%	15	18
58%	14	18
59%	14	17

BLEND	@1.4	@1.6
60%	13	17
61%	13	16
62%	13	16
63%	12	15
64%	12	15
65%	12	15
66%	11	14
67%	11	14
68%	11	14
69%	10	13
70%	10	13
71%	10	13
72%	9	12
73%	9	12
74%	9	12
75%	9	11
76%	8	11
77%	8	11
78%	8	11
79%	8	10
80%	8	10
81%	7	10
82%	7	10
83%	7	9
84%	7	9
85%	6	9
86%	6	9
87%	6	8
88%	6	8
89%	6	8
90%	6	8
91%	5	8
92%	5	7
93%	5	7
94%	5	7
95%	5	7
96%	5	7
97%	4	6
98%	4	6
99%	4	6
100%	4	6

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE IMPERIAL

OXYGEN CONTENT 21%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	10	0.27	—	0.00%
15	15	0.31	—	0.00%
20	20	0.34	—	0.00%
30	30	0.40	—	0.00%
40	40	0.46	—	0.00%
50	50	0.53	0.09	0.14%
60	60	0.59	0.24	0.14%
70	70	0.66	0.38	0.17%
80	80	0.72	0.50	0.22%
90	90	0.78	0.62	0.22%
100	100	0.85	0.74	0.28%
110	110	0.91	0.85	0.33%
120	120	0.97	0.96	0.33%
130	130	1.04	1.06	0.42%
140	140	1.10	1.16	0.42%
150	150	1.16	1.27	0.48%
160	160	1.23	1.37	0.55%
170	170	1.29	1.46	0.55%
180	180	1.36	1.56	0.67%

OXYGEN CONTENT 22%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	9	0.29	—	0.00%
15	14	0.32	—	0.00%
20	19	0.35	—	0.00%
30	29	0.42	—	0.00%
40	39	0.49	—	0.00%
50	49	0.55	0.16	0.14%
60	59	0.62	0.31	0.17%
70	69	0.69	0.44	0.17%
80	79	0.75	0.57	0.22%
90	88	0.82	0.69	0.28%
100	98	0.89	0.81	0.28%
110	108	0.95	0.92	0.33%%
120	118	1.02	1.03	0.42%
130	128	1.09	1.14	0.42%
140	138	1.15	1.25	0.48%
150	148	1.22	1.35	0.55%
160	158	1.29	1.46	0.55%
170	167	1.35	1.56	0.67%
180	177	1.42	1.66	0.83%

OXYGEN CONTENT 23%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	9	0.30	—	0.00%
15	14	0.33	—	0.00%
20	19	0.37	—	0.00%
30	28	0.44	—	0.00%
40	38	0.51	0.03	0.14%
50	48	0.58	0.22	0.14%
60	58	0.65	0.36	0.17%
70	67	0.72	0.50	0.22%
80	77	0.79	0.63	0.22%
90	87	0.86	0.76	0.28%
100	97	0.93	0.88	0.33%
110	106	1.00	0.99	0.33%
120	116	1.07	1.11	0.42%
130	126	1.14	1.22	0.48%
140	136	1.21	1.33	0.55%
150	145	1.28	1.44	0.55%
160	155	1.35	1.55	0.67%
170	165	1.41	1.65	0.83%
180	175	1.48	1.75	0.83%

OXYGEN CONTENT 24%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	8	0.31	—	0.00%
15	13	0.35	—	0.00%
20	18	0.39	—	0.00%
30	28	0.46	—	0.00%
40	37	0.53	0.10	0.14%
50	47	0.60	0.27	0.14%
60	56	0.68	0.42	0.17%
70	66	0.75	0.56	0.22%
80	76	0.82	0.69	0.28%
90	85	0.89	0.82	0.28%
100	95	0.97	0.95	0.33%
110	105	1.04	1.07	0.42%
120	114	1.11	1.18	0.48%
130	124	1.19	1.30	0.48%
140	133	1.26	1.41	0.55%
150	143	1.33	1.52	0.67%
160	153	1.40	1.63	0.67%
170	162	1.48	1.74	0.83%
180	172	1.55	1.85	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 25%

Depth	EAD	PO2	OTU / Min	CNS% Min
10	8	0.33	—	0.00%
15	13	0.36	—	0.00%
20	17	0.40	—	0.00%
30	27	0.48	—	0.00%
40	36	0.55	0.16	0.14%
50	46	0.63	0.32	0.17%
60	55	0.70	0.48	0.17%
70	65	0.78	0.62	0.22%
80	74	0.86	0.75	0.28%
90	84	0.93	0.89	0.33%
100	93	1.01	1.01	0.42%
110	103	1.08	1.14	0.42%
120	112	1.16	1.26	0.48%
130	122	1.23	1.38	0.55%
140	131	1.31	1.49	0.67%
150	141	1.39	1.61	0.67%
160	150	1.46	1.72	0.83%
170	160	1.54	1.83	2.22%
180	169	1.61	1.94	2.22%

OXYGEN CONTENT 26%

Depth	EAD	PO2	OTU / Min	CNS% Min
10	7	0.34	—	0.00%
15	12	0.38	—	0.00%
20	17	0.42	—	0.00%
30	26	0.50	—	0.00%
40	35	0.58	0.21	0.14%
50	45	0.65	0.38	0.17%
60	54	0.73	0.53	0.22%
70	63	0.81	0.68	0.28%
80	73	0.89	0.81	0.28%
90	82	0.97	0.95	0.33%
100	92	1.05	1.08	0.42%
110	101	1.13	1.21	0.48%
120	110	1.21	1.33	0.55%
130	120	1.28	1.45	0.55%
140	129	1.36	1.57	0.67%
150	138	1.44	1.69	0.83%
160	148	1.52	1.81	2.22%
170	157	1.60	1.92	2.22%

OXYGEN CONTENT 27%

Depth	EAD	PO2	OTU / Min	CNS% Min
10	7	0.35	—	0.00%
15	11	0.39	—	0.00%
20	16	0.43	—	0.00%
30	25	0.52	0.06	0.14%
40	34	0.60	0.26	0.14%
50	44	0.68	0.43	0.17%
60	53	0.76	0.58	0.22%
70	62	0.84	0.73	0.28%
80	71	0.92	0.87	0.33%
90	81	1.01	1.01	0.42%
100	90	1.09	1.14	0.42%
110	99	1.17	1.27	0.48%
120	108	1.25	1.40	0.55%
130	118	1.33	1.53	0.67%
140	127	1.42	1.65	0.83%
150	136	1.50	1.77	0.83%
160	145	1.58	1.89	2.22%

OXYGEN CONTENT 28%

Depth	EAD	PO2	OTU / Min	CNS% Min
10 6	0.36	—	0.00%	
15	11	0.41	—	0.00%
20	15	0.45	—	0.00%
30	24	0.53	0.11	0.14%
40	34	0.62	0.30	0.17%
50	43	0.70	0.48	0.17%
60	52	0.79	0.63	0.22%
70	61	0.87	0.79	0.28%
80	70	0.96	0.93	0.33%
90	79	1.04	1.07	0.42%
100	88	1.13	1.21	0.48%
110	97	1.21	1.34	0.55%
120	106	1.30	1.47	0.55%
130	116	1.38	1.60	0.67%
140	125	1.47	1.73	0.83%
150	134	1.55	1.86	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 29%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	6	0.38	—	0.00%
15	10	0.42	—	0.00%
20	15	0.47	—	0.00%
30	24	0.55	0.16	0.14%
40	33	0.64	0.35	0.17%
50	42	0.73	0.52	0.22%
60	51	0.82	0.69	0.28%
70	60	0.91	0.84	0.33%
80	69	0.99	0.99	0.33%
90	78	1.08	1.13	0.42%
100	87	1.17	1.27	0.48%
110	96	1.26	1.41	0.55%
120	105	1.34	1.55	0.67%
130	113	1.43	1.68	0.83%
140	122	1.52	1.81	2.22%
150	131	1.61	1.94	2.22%

OXYGEN CONTENT 30%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	5	0.39	—	0.00%
15	10	0.44	—	0.00%
20	14	0.48	—	0.00%
30	23	0.57	0.20	0.14%
40	32	0.66	0.40	0.17%
50	41	0.75	0.57	0.22%
60	49	0.85	0.74	0.28%
70	58	0.94	0.89	0.33%
80	67	1.03	1.05	0.42%
90	76	1.12	1.19	0.48%
100	85	1.21	1.34	0.55%
110	94	1.30	1.48	0.55%
120	103	1.39	1.62	0.67%
130	111	1.48	1.75	0.83%
140	120	1.57	1.88	2.22%

OXYGEN CONTENT 31%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	5	0.40	—	0.00%
15	9	0.45	—	0.00%
20	13	0.50	—	0.00%
30	22	0.59	0.24	0.14%
40	31	0.69	0.44	0.17%
50	39	0.78	0.62	0.22%
60	48	0.87	0.79	0.28%
70	57	0.97	0.95	0.33%
80	66	1.06	1.10	0.42%
90	74	1.16	1.25	0.48%
100	83	1.25	1.40	0.55%
110	92	1.34	1.54	0.67%
120	101	1.44	1.68	0.83%
130	109	1.53	1.82	2.22%

OXYGEN CONTENT 32%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	4	0.42	—	0.00%
15	8	0.47	—	0.00%
20	13	0.51	0.05	0.14%
30	21	0.61	0.29	0.17%
40	30	0.71	0.48	0.22%
50	38	0.80	0.66	0.22%
60	47	0.90	0.83	0.28%
70	56	1.00	1.00	0.33%
80	64	1.10	1.16	0.42%
90	73	1.19	1.31	0.48%
100	81	1.29	1.46	0.55%
110	90	1.39	1.61	0.67%
120	99	1.48	1.75	0.83%
130	107	1.58	1.90	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 33%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	3	0.43	—	0.00%
15	8	0.48	—	0.00%
20	12	0.53	0.10	0.14%
30	20	0.63	0.33	0.17%
40	29	0.73	0.52	0.22%
50	37	0.83	0.71	0.28%
60	46	0.93	0.88	0.33%
70	54	1.03	1.05	0.42%
80	63	1.13	1.21	0.48%
90	71	1.23	1.37	0.55%
100	80	1.33	1.52	0.67%
110	88	1.43	1.67	0.83%
120	97	1.53	1.82	2.22%

OXYGEN CONTENT 34%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	3	0.44	—	0.00%
15	7	0.49	—	0.00%
20	11	0.55	0.14	0.14%
30	20	0.65	0.37	0.17%
40	28	0.75	0.57	0.22%
50	36	0.86	0.75	0.28%
60	45	0.96	0.93	0.33%
70	53	1.06	1.10	0.42%
80	61	1.16	1.27	0.48%
90	70	1.27	1.43	0.55%
100	78	1.37	1.58	0.67%
110	86	1.47	1.74	0.83%
120	95	1.58	1.89	2.22%

OXYGEN CONTENT 35%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	2	0.46	—	0.00%
15	6	0.51	0.04	0.14%
20	11	0.56	0.18	0.14%
30	19	0.67	0.40	0.17%
40	27	0.77	0.61	0.22%
50	35	0.88	0.80	0.28%
60	44	0.99	0.98	0.33%
70	52	1.09	1.15	0.42%
80	60	1.20	1.32	0.48%
90	68	1.30	1.48	0.55%
100	76	1.41	1.64	0.83%
110	85	1.52	1.80	2.22%

OXYGEN CONTENT 36%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	2	0.47	—	0.00%
15	6	0.52	0.08	0.14%
20	10	0.58	0.21	0.14%
30	18	0.69	0.44	0.17%
40	26	0.80	0.65	0.22%
50	34	0.91	0.84	0.33%
60	42	1.01	1.02	0.42%
70	50	1.12	1.20	0.48%
80	59	1.23	1.37	0.55%
90	67	1.34	1.54	0.67%
100	75	1.45	1.70	0.83%
110	83	1.56	1.87	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 37%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	1	0.48	#NUM!	0.00%
15	5	0.54	0.12	0.14%
20	9	0.59	0.25	0.14%
30	17	0.71	0.48	0.22%
40	25	0.82	0.69	0.28%
50	33	0.93	0.88	0.33%
60	41	1.04	1.07	0.42%
70	49	1.15	1.25	0.48%
80	57	1.27	1.43	0.55%
90	65	1.38	1.60	0.67%
100	73	1.49	1.76	0.83%
110	81	1.60	1.93	2.22%

OXYGEN CONTENT 38%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	1	0.50	#NUM!	0.00%
15	5	0.55	0.15	0.14%
20	9	0.61	0.29	0.17%
30	16	0.73	0.52	0.22%
40	24	0.84	0.73	0.28%
50	32	0.96	0.93	0.33%
60	40	1.07	1.12	0.42%
70	48	1.19	1.30	0.48%
80	56	1.30	1.48	0.55%
90	64	1.42	1.65	0.83%
100	71	1.53	1.82	2.22%

OXYGEN CONTENT 39%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	0	0.51	0.03	0.14%
15	4	0.57	0.19	0.14%
20	8	0.63	0.32	0.17%
30	16	0.74	0.55	0.22%
40	23	0.86	0.77	0.28%
50	31	0.98	0.97	0.33%
60	39	1.10	1.16	0.42%
70	47	1.22	1.35	0.55%
80	54	1.34	1.53	0.67%
90	62	1.45	1.71	0.83%
100	70	1.57	1.88	2.22%

OXYGEN CONTENT 40%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	0	0.52	0.07	0.14%
15	3	0.58	0.22	0.14%
20	7	0.64	0.35	0.17%
30	15	0.76	0.59	0.22%
40	22	0.88	0.80	0.28%
50	30	1.01	1.01	0.42%
60	38	1.13	1.21	0.48%
70	45	1.25	1.40	0.55%
80	53	1.37	1.58	0.67%
90	60	1.49	1.76	0.83%
100	68	1.61	1.94	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 41%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-1	0.53	0.11	0.14%
15	3	0.60	0.25	0.14%
20	7	0.66	0.39	0.17%
30	14	0.78	0.62	0.22%
40	22	0.91	0.84	0.33%
50	29	1.03	1.05	0.42%
60	36	1.16	1.25	0.48%
70	44	1.28	1.45	0.55%
80	51	1.40	1.63	0.67%
90	59	1.53	1.82	2.22%

OXYGEN CONTENT 42%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-1	0.55	0.14	0.14%
15	2	0.61	0.29	0.17%
20	6	0.67	0.42	0.17%
30	13	0.80	0.66	0.22%
40	21	0.93	0.88	0.33%
50	28	1.06	1.09	0.42%
60	35	1.18	1.30	0.48%
70	43	1.31	1.49	0.67%
80	50	1.44	1.69	0.83%
90	57	1.57	1.87	2.22%

OXYGEN CONTENT 43%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-2	0.56	0.17	0.14%
15	2	0.63	0.32	0.17%
20	5	0.69	0.45	0.17%
30	12	0.82	0.69	0.28%
40	20	0.95	0.92	0.33%
50	27	1.08	1.13	0.42%
60	34	1.21	1.34	0.55%
70	41	1.34	1.54	0.67%
80	49	1.47	1.74	0.83%
90	56	1.60	1.93	2.22%

OXYGEN CONTENT 44%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-3	0.57	0.20	0.14%
15	1	0.64	0.35	0.17%
20	5	0.71	0.48	0.22%
30	12	0.84	0.73	0.28%
40	19	0.97	0.96	0.33%
50	26	1.11	1.17	0.48%
60	33	1.24	1.38	0.55%
70	40	1.37	1.59	0.67%
80	47	1.51	1.79	2.22%

OXYGEN CONTENT 45%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-3	0.59	0.23	0.14%
15	0	0.65	0.38	0.17%
20	4	0.72	0.51	0.22%
30	11	0.86	0.76	0.28%
40	18	1.00	0.99	0.33%
50	25	1.13	1.21	0.48%
60	32	1.27	1.43	0.55%
70	39	1.40	1.64	0.67%
80	46	1.54	1.84	2.22%

OXYGEN CONTENT 46%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-4	0.60	0.26	0.14%
15	0	0.67	0.41	0.17%
20	3	0.74	0.54	0.22%
30	10	0.88	0.79	0.28%
40	17	1.02	1.03	0.42%
50	24	1.16	1.25	0.48%
60	31	1.30	1.47	0.55%
70	37	1.44	1.68	0.83%
80	44	1.58	1.89	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 47%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-4	0.61	0.29	0.17%
15	-1	0.68	0.44	0.17%
20	3	0.75	0.57	0.22%
30	9	0.90	0.83	0.28%
40	16	1.04	1.07	0.42%
50	23	1.18	1.29	0.48%
60	29	1.32	1.51	0.67%
70	36	1.47	1.73	0.83%
80	43	1.61	1.94	2.22%

OXYGEN CONTENT 48%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-5	0.63	0.32	0.17%
15	-1	0.70	0.46	0.17%
20	2	0.77	0.60	0.22%
30	8	0.92	0.86	0.33%
40	15	1.06	1.10	0.42%
50	22	1.21	1.33	0.55%
60	28	1.35	1.56	0.67%
70	35	1.50	1.78	0.83%

OXYGEN CONTENT 49%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-5	0.64	0.34	0.17%
15	-2	0.71	0.49	0.22%
20	1	0.79	0.63	0.22%
30	8	0.94	0.89	0.33%
40	14	1.08	1.14	0.42%
50	21	1.23	1.37	0.55%
60	27	1.38	1.60	0.67%
70	33	1.53	1.82	2.22%

OXYGEN CONTENT 50%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-6	0.65	0.37	0.17%
15	-3	0.73	0.52	0.22%
20	1	0.80	0.66	0.22%
30	7	0.95	0.92	0.33%
40	13	1.11	1.17	0.48%
50	20	1.26	1.41	0.55%
60	26	1.41	1.64	0.83%
70	32	1.56	1.87	2.22%

OXYGEN CONTENT 51%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-6	0.66	0.40	0.17%
15	-3	0.74	0.55	0.22%
20	0	0.82	0.69	0.28%
30	6	0.97	0.96	0.33%
40	12	1.13	1.21	0.48%
50	18	1.28	1.45	0.55%
60	25	1.44	1.68	0.83%
70	31	1.59	1.91	2.22%

OXYGEN CONTENT 52%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-7	0.68	0.42	0.17%
15	-4	0.76	0.57	0.22%
20	-1	0.84	0.72	0.28%
30	5	0.99	0.99	0.33%
40	11	1.15	1.24	0.48%
50	17	1.31	1.49	0.67%
60	24	1.47	1.73	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 53%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-7	0.69	0.45	0.17%
15	-4	0.77	0.60	0.22%
20	-1	0.85	0.75	0.28%
30	4	1.01	1.02	0.42%
40	10	1.17	1.28	0.48%
50	16	1.33	1.53	0.67%
60	22	1.49	1.77	0.83%

OXYGEN CONTENT 54%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-8	0.70	0.47	0.17%
15	-5	0.79	0.63	0.22%
20	-2	0.87	0.77	0.28%
30	4	1.03	1.05	0.42%
40	10	1.19	1.31	0.48%
50	15	1.36	1.57	0.67%
60	21	1.52	1.81	2.22%

OXYGEN CONTENT 55%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-9	0.72	0.50	0.22%
15	-6	0.80	0.65	0.22%
20	-3	0.88	0.80	0.28%
30	3	1.05	1.08	0.42%
40	9	1.22	1.35	0.55%
50	14	1.38	1.60	0.67%
60	20	1.55	1.85	2.22%

OXYGEN CONTENT 56%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-9	0.73	0.52	0.22%
15	-6	0.81	0.68	0.28%
20	-3	0.90	0.83	0.28%
30	2	1.07	1.11	0.42%
40	8	1.24	1.38	0.55%
50	13	1.41	1.64	0.83%
60	19	1.58	1.89	2.22%

OXYGEN CONTENT 57%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-10	0.74	0.55	0.22%
15	-7	0.83	0.71	0.28%
20	-4	0.92	0.86	0.33%
30	1	1.09	1.14	0.42%
40	7	1.26	1.42	0.55%
50	12	1.43	1.68	0.83%
60	18	1.61	1.93	2.22%

OXYGEN CONTENT 58%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-10	0.76	0.57	0.22%
15	-7	0.84	0.73	0.28%
20	-5	0.93	0.88	0.33%
30	0	1.11	1.18	0.48%
40	6	1.28	1.45	0.55%
50	11	1.46	1.72	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 59%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-11	0.77	0.60	0.22%
15	-8	0.86	0.76	0.28%
20	-5	0.95	0.91	0.33%
30	0	1.13	1.21	0.48%
40	5	1.31	1.49	0.67%
50	10	1.48	1.75	0.83%

OXYGEN CONTENT 60%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-11	0.78	0.62	0.22%
15	-9	0.87	0.78	0.28%
20	-6	0.96	0.94	0.33%
30	-1	1.15	1.24	0.48%
40	4	1.33	1.52	0.67%
50	9	1.51	1.79	2.22%

OXYGEN CONTENT 61%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-12	0.79	0.65	0.22%
15	-9	0.89	0.81	0.28%
20	-7	0.98	0.97	0.33%
30	-2	1.16	1.27	0.48%
40	3	1.35	1.55	0.67%
50	8	1.53	1.83	2.22%

OXYGEN CONTENT 62%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-12	0.81	0.67	0.28%
15	-10	0.90	0.83	0.28%
20	-8	1.00	0.99	0.33%
30	-3	1.18	1.30	0.48%
40	2	1.37	1.59	0.67%
50	7	1.56	1.86	2.22%

OXYGEN CONTENT 63%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-13	0.82	0.69	0.28%
15	-11	0.92	0.86	0.33%
20	-8	1.01	1.02	0.42%
30	-3	1.20	1.33	0.48%
40	1	1.39	1.62	0.67%
50	6	1.58	1.90	2.22%

OXYGEN CONTENT 64%

Depth	EAD	PO_2	OTU / Min	CNS% Mi
10	-13	0.83	0.72	0.28%
15	-11	0.93	0.88	0.33%
20	-9	1.03	1.05	0.42%
30	-4	1.22	1.36	0.55%
40	0	1.42	1.65	0.83%
50	5	1.61	1.94	2.22%

OXYGEN CONTENT 65%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-14	0.85	0.74	0.28%
15	-12	0.95	0.91	0.33%
20	-10	1.04	1.07	0.42%
30	-5	1.24	1.39	0.55%
40	-1	1.44	1.69	0.83%

OXYGEN CONTENT 66%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-14	0.86	0.76	0.28%
15	-12	0.96	0.93	0.33%
20	-10	1.06	1.10	0.42%
30	-6	1.26	1.42	0.55%
40	-2	1.46	1.72	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 67%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-15	0.87	0.78	0.28%
15	-13	0.97	0.96	0.33%
20	-11	1.08	1.12	0.42%
30	-7	1.28	1.45	0.55%
40	-3	1.48	1.75	0.83%

OXYGEN CONTENT 68%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-16	0.89	0.81	0.28%
15	-14	0.99	0.98	0.33%
20	-12	1.09	1.15	0.42%
30	-7	1.30	1.47	0.55%
40	-3	1.50	1.78	0.83%

OXYGEN CONTENT 69%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-16	0.90	0.83	0.28%
15	-14	1.00	1.01	0.33%
20	-12	1.11	1.18	0.48%
30	-8	1.32	1.50	0.67%
40	-4	1.53	1.82	2.22%

OXYGEN CONTENT 70%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-17	0.91	0.85	0.33%
15	-15	1.02	1.03	0.42%
20	-13	1.12	1.20	0.48%
30	-9	1.34	1.53	0.67%
40	-5	1.55	1.85	2.22%

OXYGEN CONTENT 71%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-17	0.93	0.87	0.33%
15	-15	1.03	1.05	0.42%
20	-14	1.14	1.23	0.48%
30	-10	1.36	1.56	0.67%
40	-6	1.57	1.88	2.22%

OXYGEN CONTENT 72%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-18	0.94	0.90	0.33%
15	-16	1.05	1.08	0.42%
20	-14	1.16	1.25	0.48%
30	-11	1.37	1.59	0.67%
40	-7	1.59	1.91	2.22%

OXYGEN CONTENT 73%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-18	0.95	0.92	0.33%
15	-17	1.06	1.10	0.42%
20	-15	1.17	1.28	0.48%
30	-11	1.39	1.62	0.67%
40	-8	1.61	1.95	2.22%

OXYGEN CONTENT 74%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-19	0.96	0.94	0.33%
15	-17	1.08	1.13	0.42%
20	-16	1.19	1.30	0.48%
30	-12	1.41	1.65	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 75%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-19	0.98	0.96	0.33%
15	-18	1.09	1.15	0.42%
20	-16	1.20	1.33	0.48%
30	-13	1.43	1.68	0.83%

OXYGEN CONTENT 76%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-20	0.99	0.98	0.33%
15	-18	1.11	1.17	0.48%
20	-17	1.22	1.35	0.55%
30	-14	1.45	1.70	0.83%

OXYGEN CONTENT 77%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-20	1.00	1.01	0.33%
15	-19	1.12	1.20	0.48%
20	-18	1.24	1.38	0.55%
30	-15	1.47	1.73	0.83%

OXYGEN CONTENT 78%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-21	1.02	1.03	0.42%
15	-20	1.13	1.22	0.48%
20	-18	1.25	1.40	0.55%
30	-15	1.49	1.76	0.83%

OXYGEN CONTENT 79%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-22	1.03	1.05	0.42%
15	-20	1.15	1.24	0.48%
20	-19	1.27	1.43	0.55%
30	-16	1.51	1.79	2.22%

OXYGEN CONTENT 80%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-22	1.04	1.07	0.42%
15	-21	1.16	1.26	0.48%
20	-20	1.28	1.45	0.55%
30	-17	1.53	1.82	2.22%

OXYGEN CONTENT 81%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-23	1.06	1.09	0.42%
15	-21	1.18	1.29	0.48%
20	-20	1.30	1.48	0.55%
30	-18	1.55	1.85	2.22%

OXYGEN CONTENT 82%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-23	1.07	1.11	0.42%
15	-22	1.19	1.31	0.48%
20	-21	1.32	1.50	0.67%
30	-19	1.57	1.87	2.22%

OXYGEN CONTENT 83%

Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-24	1.08	1.13	0.42%
15	-23	1.21	1.33	0.55%
20	-22	1.33	1.53	0.67%
30	-19	1.58	1.90	2.22%

OXYGEN CONTENT 84%

Depth Min	EAD	PO_2	OTU / Min	CNS%
10	-24	1.09	1.15	0.42%
15	-23	1.22	1.36	0.55%
20	-22	1.35	1.55	0.67%
30	-20	1.60	1.93	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 85%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-25	1.11	1.18	0.48%
15	-24	1.24	1.38	0.55%
20	-23	1.37	1.58	0.67%

OXYGEN CONTENT 86%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-25	1.12	1.20	0.48%
15	-24	1.25	1.40	0.55%
20	-24	1.38	1.60	0.67%

OXYGEN CONTENT 87%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-26	1.13	1.22	0.48%
15	-25	1.27	1.42	0.55%
20	-24	1.40	1.62	0.67%

OXYGEN CONTENT 88%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-26	1.15	1.24	0.48%
15	-26	1.28	1.45	0.55%
20	-25	1.41	1.65	0.83%

OXYGEN CONTENT 89%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-27	1.16	1.26	0.48%
15	-26	1.29	1.47	0.55%
20	-26	1.43	1.67	0.83%

OXYGEN CONTENT 90%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-28	1.17	1.28	0.48%
15	-27	1.31	1.49	0.67%
20	-26	1.45	1.70	0.83%

OXYGEN CONTENT 91%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-28	1.19	1.30	0.48%
15	-28	1.32	1.51	0.67%
20	-27	1.46	1.72	0.83%

OXYGEN CONTENT 92%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-29	1.20	1.32	0.48%
15	-28	1.34	1.54	0.67%
20	-28	1.48	1.74	0.83%

OXYGEN CONTENT 93%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-29	1.21	1.34	0.55%
15	-29	1.35	1.56	0.67%
20	-28	1.49	1.77	0.83%

OXYGEN CONTENT 94%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-30	1.22	1.36	0.55%
15	-29	1.37	1.58	0.67%
20	-29	1.51	1.79	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – IMPERIAL (continued)

OXYGEN CONTENT 95%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-30	1.24	1.38	0.55%
15	-30	1.38	1.60	0.67%
20	-30	1.53	1.82	2.22%

OXYGEN CONTENT 96%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-31	1.25	1.40	0.55%
15	-31	1.40	1.62	0.67%
20	-30	1.54	1.84	2.22%

OXYGEN CONTENT 97%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-31	1.26	1.42	0.55%
15	-31	1.41	1.65	0.83%
20	-31	1.56	1.86	2.22%

OXYGEN CONTENT 98%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-32	1.28	1.44	0.55%
15	-32	1.43	1.67	0.83%
20	-32	1.57	1.89	2.22%

OXYGEN CONTENT 99%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-32	1.29	1.46	0.55%
15	-32	1.44	1.69	0.83%
20	-32	1.59	1.91	2.22%

OXYGEN CONTENT 100%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
10	-33	1.30	1.48	0.55%
15	-33	1.45	1.71	0.83%
20	-33	1.61	1.93	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE METRIC

OXYGEN CONTENT 21%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	3.0	0.27	—	0.00%
5	5.0	0.32	—	0.00%
6	6.0	0.34	—	0.00%
9	9.0	0.40	—	0.00%
12	12.0	0.46	—	0.00%
15	15.0	0.53	0.08	0.00%
18	18.0	0.59	0.24	0.14%
21	21.0	0.65	0.37	0.17%
24	24.0	0.71	0.49	0.22%
27	27.0	0.78	0.61	0.22%
30	30.0	0.84	0.73	0.28%
33	33.0	0.90	0.84	0.28%
36	36.0	0.97	0.94	0.33%
39	39.0	1.03	1.05	0.42%
42	42.0	1.09	1.15	0.42%
45	45.0	1.16	1.25	0.48%
48	48.0	1.22	1.35	0.55%
51	51.0	1.28	1.45	0.55%
54	54.0	1.34	1.54	0.67%
57	57.0	1.41	1.64	0.83%

OXYGEN CONTENT 22%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.8	0.29	—	0.00%
5	4.8	0.33	—	0.00%
6	5.8	0.35	—	0.00%
9	8.8	0.42	—	0.00%
12	11.7	0.48	—	0.00%
15	14.7	0.55	0.15	0.14%
18	17.6	0.62	0.30	0.17%
21	20.6	0.68	0.43	0.17%
24	23.6	0.75	0.56	0.22%
27	26.5	0.81	0.68	0.28%
30	29.5	0.88	0.80	0.28%
33	32.5	0.95	0.91	0.33%
36	35.4	1.01	1.02	0.42%
39	38.4	1.08	1.13	0.42%
42	41.3	1.14	1.23	0.48%
45	44.3	1.21	1.34	0.55%
48	47.3	1.28	1.44	0.55%
51	50.2	1.34	1.54	0.67%
54	53.2	1.41	1.64	0.83%
57	56.2	1.47	1.74	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE METRIC

OXYGEN CONTENT 23%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.7	0.30	—	0.00%
5	4.6	0.35	—	0.00%
6	5.6	0.37	—	0.00%
9	8.5	0.44	—	0.00%
12	11.4	0.51	0.03	0.14%
15	14.4	0.58	0.21	0.14%
18	17.3	0.64	0.36	0.17%
21	20.2	0.71	0.49	0.22%
24	23.1	0.78	0.62	0.22%
27	26.1	0.85	0.75	0.28%
30	29.0	0.92	0.87	0.33%
33	31.9	0.99	0.98	0.33%
36	34.8	1.06	1.10	0.42%
39	37.8	1.13	1.21	0.48%
42	40.7	1.20	1.32	0.48%
45	43.6	1.27	1.42	0.55%
48	46.5	1.33	1.53	0.67%
51	49.5	1.40	1.63	0.67%
54	52.4	1.47	1.74	0.83%
57	55.3	1.54	1.84	2.22%

OXYGEN CONTENT 24%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.5	0.31	—	0.00%
5	4.4	0.36	—	0.00%
6	5.4	0.38	—	0.00%
9	8.3	0.46	—	0.00%
12	11.2	0.53	0.09	0.14%
15	14.1	0.60	0.26	0.14%
18	16.9	0.67	0.41	0.17%
21	19.8	0.74	0.55	0.22%
24	22.7	0.82	0.68	0.28%
27	25.6	0.89	0.81	0.28%
30	28.5	0.96	0.93	0.33%
33	31.4	1.03	1.05	0.42%
36	34.3	1.10	1.17	0.42%
39	37.1	1.18	1.28	0.48%
42	40.0	1.25	1.40	0.55%
45	42.9	1.32	1.51	0.67%
48	45.8	1.39	1.62	0.67%
51	48.7	1.46	1.72	0.83%
54	51.6	1.54	1.83	2.22%
57	54.5	1.61	1.94	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 25%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.3	0.33	—	0.00%
5	4.2	0.38	—	0.00%
6	5.2	0.40	—	0.00%
9	8.0	0.48	—	0.00%
12	10.9	0.55	0.15	0.14%
15	13.7	0.63	0.32	0.17%
18	16.6	0.70	0.47	0.17%
21	19.4	0.78	0.61	0.22%
24	22.3	0.85	0.74	0.28%
27	25.1	0.93	0.87	0.33%
30	28.0	1.00	1.00	0.33%
33	30.8	1.08	1.12	0.42%
36	33.7	1.15	1.24	0.48%
39	36.5	1.23	1.36	0.55%
42	39.4	1.30	1.48	0.55%
45	42.2	1.38	1.59	0.67%
48	45.1	1.45	1.70	0.83%
51	47.9	1.53	1.81	2.22%
54	50.8	1.60	1.92	2.22%

OXYGEN CONTENT 26%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.2	0.34	—	0.00%
5	4.1	0.39	—	0.00%
6	5.0	0.42	—	0.00%
9	7.8	0.49	—	0.00%
12	10.6	0.57	0.20	0.14%
15	13.4	0.65	0.37	0.17%
18	16.2	0.73	0.52	0.22%
21	19.0	0.81	0.67	0.28%
24	21.8	0.88	0.80	0.28%
27	24.7	0.96	0.94	0.33%
30	27.5	1.04	1.07	0.42%
33	30.3	1.12	1.19	0.48%
36	33.1	1.20	1.32	0.48%
39	35.9	1.27	1.44	0.55%
42	38.7	1.35	1.56	0.67%
45	41.5	1.43	1.67	0.83%
48	44.3	1.51	1.79	2.22%
51	47.1	1.59	1.90	2.22%

OXYGEN CONTENT 27%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	2.0	0.35	—	0.00%
5	3.9	0.41	—	0.00%
6	4.8	0.43	—	0.00%
9	7.6	0.51	0.05	0.14%
12	10.3	0.59	0.25	0.14%
15	13.1	0.68	0.42	0.17%
18	15.9	0.76	0.57	0.22%
21	18.6	0.84	0.72	0.28%
24	21.4	0.92	0.86	0.33%
27	24.2	1.00	1.00	0.33%
30	27.0	1.08	1.13	0.42%
33	29.7	1.16	1.26	0.48%
36	32.5	1.24	1.39	0.55%
39	35.3	1.32	1.51	0.67%
42	38.1	1.40	1.63	0.67%
45	40.8	1.49	1.76	0.83%
48	43.6	1.57	1.87	2.22%

OXYGEN CONTENT 28%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.8	0.36	—	0.00%
5	3.7	0.42	—	0.00%
6	4.6	0.45	—	0.00%
9	7.3	0.53	0.10	0.14%
12	10.1	0.62	0.30	0.17%
15	12.8	0.70	0.47	0.17%
18	15.5	0.78	0.63	0.22%
21	18.3	0.87	0.78	0.28%
24	21.0	0.95	0.92	0.33%
27	23.7	1.04	1.06	0.42%
30	26.5	1.12	1.20	0.48%
33	29.2	1.20	1.33	0.48%
36	31.9	1.29	1.46	0.55%
39	34.7	1.37	1.59	0.67%
42	37.4	1.46	1.71	0.83%
45	40.1	1.54	1.84	2.22%
48	42.9	1.62	1.96	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 29%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.7	0.38	—	0.00%
5	3.5	0.44	—	0.00%
6	4.4	0.46	—	0.00%
9	7.1	0.55	0.15	0.14%
12	9.8	0.64	0.34	0.17%
15	12.5	0.73	0.52	0.22%
18	15.2	0.81	0.68	0.28%
21	17.9	0.90	0.83	0.28%
24	20.6	0.99	0.98	0.33%
27	23.3	1.07	1.12	0.42%
30	25.9	1.16	1.26	0.48%
33	28.6	1.25	1.40	0.55%
36	31.3	1.33	1.53	0.67%
39	34.0	1.42	1.66	0.83%
42	36.7	1.51	1.79	2.22%
45	39.4	1.60	1.92	2.22%

OXYGEN CONTENT 30%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.5	0.39	—	0.00%
5	3.3	0.45	—	0.00%
6	4.2	0.48	—	0.00%
9	6.8	0.57	0.20	0.14%
12	9.5	0.66	0.39	0.17%
15	12.2	0.75	0.56	0.22%
18	14.8	0.84	0.73	0.28%
21	17.5	0.93	0.88	0.33%
24	20.1	1.02	1.03	0.42%
27	22.8	1.11	1.18	0.48%
30	25.4	1.20	1.32	0.48%
33	28.1	1.29	1.46	0.55%
36	30.8	1.38	1.60	0.67%
39	33.4	1.47	1.73	0.83%
42	36.1	1.56	1.87	2.22%

OXYGEN CONTENT 31%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.4	0.40	—	0.00%
5	3.1	0.47	—	0.00%
6	4.0	0.50	—	0.00%
9	6.6	0.59	0.24	0.14%
12	9.2	0.68	0.43	0.17%
15	11.8	0.78	0.61	0.22%
18	14.5	0.87	0.78	0.28%
21	17.1	0.96	0.93	0.33%
24	19.7	1.05	1.09	0.42%
27	22.3	1.15	1.24	0.48%
30	24.9	1.24	1.38	0.55%
33	27.6	1.33	1.53	0.67%
36	30.2	1.43	1.67	0.83%
39	32.8	1.52	1.81	2.22%
42	35.4	1.61	1.94	2.22%

OXYGEN CONTENT 32%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.2	0.42	—	0.00%
5	2.9	0.48	—	0.00%
6	3.8	0.51	0.05	0.14%
9	6.4	0.61	0.28	0.17%
12	8.9	0.70	0.48	0.17%
15	11.5	0.80	0.65	0.22%
18	14.1	0.90	0.82	0.28%
21	16.7	0.99	0.99	0.33%
24	19.3	1.09	1.14	0.42%
27	21.8	1.18	1.30	0.48%
30	24.4	1.28	1.45	0.55%
33	27.0	1.38	1.59	0.67%
36	29.6	1.47	1.74	0.83%
39	32.2	1.57	1.88	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 33%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	1.0	0.43	—	0.00%
5	2.7	0.50	—	0.00%
6	3.6	0.53	0.09	0.14%
9	6.1	0.63	0.32	0.17%
12	8.7	0.73	0.52	0.22%
15	11.2	0.83	0.70	0.28%
18	13.7	0.92	0.87	0.33%
21	16.3	1.02	1.04	0.42%
24	18.8	1.12	1.20	0.48%
27	21.4	1.22	1.36	0.55%
30	23.9	1.32	1.51	0.67%
33	26.5	1.42	1.66	0.83%
36	29.0	1.52	1.80	2.22%
39	31.6	1.62	1.95	2.22%

OXYGEN CONTENT 34%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.9	0.44	—	0.00%
5	2.5	0.51	0.04	0.14%
6	3.4	0.54	0.13	0.14%
9	5.9	0.65	0.36	0.17%
12	8.4	0.75	0.56	0.22%
15	10.9	0.85	0.74	0.28%
18	13.4	0.95	0.92	0.33%
21	15.9	1.05	1.09	0.42%
24	18.4	1.16	1.25	0.48%
27	20.9	1.26	1.41	0.55%
30	23.4	1.36	1.57	0.67%
33	25.9	1.46	1.72	0.83%
36	28.4	1.56	1.87	2.22%

OXYGEN CONTENT 35%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.7	0.46	—	0.00%
5	2.3	0.53	0.08	0.14%
6	3.2	0.56	0.17	0.14%
9	5.6	0.67	0.40	0.17%
12	8.1	0.77	0.60	0.22%
15	10.6	0.88	0.79	0.28%
18	13.0	0.98	0.97	0.33%
21	15.5	1.09	1.14	0.42%
24	18.0	1.19	1.31	0.48%
27	20.4	1.30	1.47	0.55%
30	22.9	1.40	1.63	0.67%
33	25.4	1.51	1.79	2.22%
36	27.8	1.61	1.94	2.22%

OXYGEN CONTENT 36%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.5	0.47	—	0.00%
5	2.2	0.54	0.12	0.14%
6	3.0	0.58	0.21	0.14%
9	5.4	0.68	0.44	0.17%
12	7.8	0.79	0.64	0.22%
15	10.3	0.90	0.83	0.28%
18	12.7	1.01	1.01	0.42%
21	15.1	1.12	1.19	0.48%
24	17.5	1.22	1.36	0.55%
27	20.0	1.33	1.53	0.67%
30	22.4	1.44	1.69	0.83%
33	24.8	1.55	1.85	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 37%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.4	0.48	—	0.00%
5	2.0	0.56	0.16	0.14%
6	2.8	0.59	0.25	0.14%
9	5.2	0.70	0.47	0.17%
12	7.5	0.81	0.68	0.28%
15	9.9	0.93	0.87	0.33%
18	12.3	1.04	1.06	0.42%
21	14.7	1.15	1.24	0.48%
24	17.1	1.26	1.41	0.55%
27	19.5	1.37	1.58	0.67%
30	21.9	1.48	1.75	0.83%
33	24.3	1.59	1.91	2.22%

OXYGEN CONTENT 38%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.2	0.49	—	0.00%
5	1.8	0.57	0.20	0.00%
6	2.6	0.61	0.28	0.17%
9	4.9	0.72	0.51	0.22%
12	7.3	0.84	0.72	0.28%
15	9.6	0.95	0.92	0.33%
18	12.0	1.06	1.11	0.42%
21	14.3	1.18	1.29	0.48%
24	16.7	1.29	1.46	0.55%
27	19.0	1.41	1.64	0.83%
30	21.4	1.52	1.81	2.22%

OXYGEN CONTENT 39%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	0.0	0.51	0.03	0.14%
5	1.6	0.59	0.23	0.14%
6	2.4	0.62	0.31	0.17%
9	4.7	0.74	0.55	0.22%
12	7.0	0.86	0.76	0.28%
15	9.3	0.98	0.96	0.33%
18	11.6	1.09	1.15	0.42%
21	13.9	1.21	1.34	0.55%
24	16.3	1.33	1.52	0.67%
27	18.6	1.44	1.69	0.83%
30	20.9	1.56	1.87	2.22%

OXYGEN CONTENT 40%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.1	0.52	0.07	0.14%
5	1.4	0.60	0.26	0.14%
6	2.2	0.64	0.35	0.17%
9	4.4	0.76	0.58	0.22%
12	6.7	0.88	0.80	0.28%
15	9.0	1.00	1.00	0.33%
18	11.3	1.12	1.20	0.48%
21	13.5	1.24	1.38	0.55%
24	15.8	1.36	1.57	0.67%
27	18.1	1.48	1.75	0.83%
30	20.4	1.60	1.92	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 41%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.3	0.53	0.10	0.14%
5	1.2	0.62	0.30	0.17%
6	1.9	0.66	0.38	0.17%
9	4.2	0.78	0.62	0.22%
12	6.4	0.90	0.83	0.28%
15	8.7	1.03	1.04	0.42%
18	10.9	1.15	1.24	0.48%
21	13.2	1.27	1.43	0.55%
24	15.4	1.39	1.62	0.67%
27	17.6	1.52	1.80	2.22%

OXYGEN CONTENT 42%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.5	0.55	0.14	0.14%
5	1.0	0.63	0.33	0.17%
6	1.7	0.67	0.41	0.17%
9	3.9	0.80	0.65	0.22%
12	6.2	0.92	0.87	0.33%
15	8.4	1.05	1.08	0.42%
18	10.6	1.18	1.28	0.48%
21	12.8	1.30	1.48	0.55%
24	15.0	1.43	1.67	0.83%
27	17.2	1.55	1.86	2.22%

OXYGEN CONTENT 43%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.6	0.56	0.17	0.14%
5	0.8	0.65	0.36	0.17%
6	1.5	0.69	0.44	0.17%
9	3.7	0.82	0.69	0.28%
12	5.9	0.95	0.91	0.33%
15	8.0	1.08	1.12	0.42%
18	10.2	1.20	1.33	0.48%
21	12.4	1.33	1.53	0.55%
24	14.5	1.46	1.72	0.83%
27	16.7	1.59	1.91	2.22%

OXYGEN CONTENT 44%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.8	0.57	0.20	0.14%
5	0.6	0.66	0.39	0.17%
6	1.3	0.70	0.48	0.17%
9	3.5	0.84	0.72	0.28%
12	5.6	0.97	0.95	0.33%
15	7.7	1.10	1.16	0.42%
18	9.8	1.23	1.37	0.55%
21	12.0	1.36	1.57	0.67%
24	14.1	1.50	1.77	0.83%

OXYGEN CONTENT 45%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-0.9	0.59	0.23	0.14%
5	0.4	0.68	0.42	0.17%
6	1.1	0.72	0.51	0.22%
9	3.2	0.86	0.75	0.28%
12	5.3	0.99	0.98	0.33%
15	7.4	1.13	1.20	0.48%
18	9.5	1.26	1.42	0.55%
21	11.6	1.40	1.62	0.67%
24	13.7	1.53	1.82	2.22%

OXYGEN CONTENT 46%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.1	0.60	0.26	0.14%
5	0.3	0.69	0.45	0.17%
6	0.9	0.74	0.54	0.22%
9	3.0	0.87	0.79	0.28%
12	5.0	1.01	1.02	0.42%
15	7.1	1.15	1.24	0.48%
18	9.1	1.29	1.46	0.55%
21	11.2	1.43	1.67	0.83%
24	13.2	1.56	1.87	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 47%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.3	0.61	0.29	0.17%
5	0.1	0.71	0.48	0.22%
6	0.7	0.75	0.57	0.22%
9	2.7	0.89	0.82	0.28%
12	4.8	1.03	1.06	0.42%
15	6.8	1.18	1.28	0.48%
18	8.8	1.32	1.50	0.67%
21	10.8	1.46	1.71	0.83%
24	12.8	1.60	1.92	2.22%

OXYGEN CONTENT 48%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.4	0.62	0.31	0.17%
5	-0.1	0.72	0.51	0.22%
6	0.5	0.77	0.60	0.22%
9	2.5	0.91	0.85	0.33%
12	4.5	1.06	1.09	0.42%
15	6.5	1.20	1.32	0.48%
18	8.4	1.34	1.54	0.67%
21	10.4	1.49	1.76	0.83%

OXYGEN CONTENT 49%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.6	0.64	0.34	0.17%
5	-0.3	0.74	0.53	0.22%
6	0.3	0.78	0.63	0.22%
9	2.3	0.93	0.88	0.33%
12	4.2	1.08	1.13	0.42%
15	6.1	1.23	1.36	0.55%
18	8.1	1.37	1.59	0.67%
21	10.0	1.52	1.81	2.22%

OXYGEN CONTENT 50%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.8	0.65	0.37	0.17%
5	-0.5	0.75	0.56	0.22%
6	0.1	0.80	0.65	0.22%
9	2.0	0.95	0.92	0.33%
12	3.9	1.10	1.16	0.42%
15	5.8	1.25	1.40	0.55%
18	7.7	1.40	1.63	0.67%
21	9.6	1.55	1.85	2.22%

OXYGEN CONTENT 51%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-1.9	0.66	0.39	0.17%
5	-0.7	0.77	0.59	0.22%
6	-0.1	0.82	0.68	0.28%
9	1.8	0.97	0.95	0.33%
12	3.6	1.12	1.20	0.48%
15	5.5	1.28	1.44	0.55%
18	7.4	1.43	1.67	0.83%
21	9.2	1.58	1.90	2.22%

OXYGEN CONTENT 52%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.1	0.68	0.42	0.17%
5	-0.9	0.78	0.62	0.22%
6	-0.3	0.83	0.71	0.28%
9	1.5	0.99	0.98	0.33%
12	3.4	1.14	1.23	0.48%
15	5.2	1.30	1.48	0.55%
18	7.0	1.46	1.71	0.83%
21	8.8	1.61	1.94	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 53%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.3	0.69	0.45	0.17%
5	-1.1	0.80	0.65	0.22%
6	-0.5	0.85	0.74	0.28%
9	1.3	1.01	1.01	0.42%
12	3.1	1.17	1.27	0.48%
15	4.9	1.33	1.52	0.67%
18	6.7	1.48	1.75	0.83%

OXYGEN CONTENT 54%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.4	0.70	0.47	0.17%
5	-1.3	0.81	0.67	0.28%
6	-0.7	0.86	0.77	0.28%
9	1.1	1.03	1.04	0.42%
12	2.8	1.19	1.30	0.48%
15	4.6	1.35	1.55	0.67%
18	6.3	1.51	1.80	2.22%

OXYGEN CONTENT 55%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.6	0.72	0.50	0.22%
5	-1.5	0.83	0.70	0.28%
6	-0.9	0.88	0.80	0.28%
9	0.8	1.05	1.07	0.42%
12	2.5	1.21	1.34	0.55%
15	4.2	1.38	1.59	0.67%
18	5.9	1.54	1.84	2.22%

OXYGEN CONTENT 56%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.8	0.73	0.52	0.22%
5	-1.6	0.84	0.73	0.28%
6	-1.1	0.90	0.82	0.28%
9	0.6	1.06	1.11	0.42%
12	2.3	1.23	1.37	0.55%
15	3.9	1.40	1.63	0.67%
18	5.6	1.57	1.88	2.22%

OXYGEN CONTENT 57%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-2.9	0.74	0.55	0.22%
5	-1.8	0.86	0.75	0.28%
6	-1.3	0.91	0.85	0.33%
9	0.3	1.08	1.14	0.42%
12	2.0	1.25	1.41	0.55%
15	3.6	1.43	1.67	0.83%
18	5.2	1.60	1.92	2.22%

OXYGEN CONTENT 58%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.1	0.75	0.57	0.22%
5	-2.0	0.87	0.78	0.28%
6	-1.5	0.93	0.88	0.33%
9	0.1	1.10	1.17	0.42%
12	1.7	1.28	1.44	0.55%
15	3.3	1.45	1.70	0.83%
18	4.9	1.62	1.96	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 59%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.3	0.77	0.59	0.22%
5	-2.2	0.89	0.80	0.28%
6	-1.7	0.94	0.91	0.33%
9	-0.1	1.12	1.20	0.48%
12	1.4	1.30	1.47	0.55%
15	3.0	1.48	1.74	0.83%

OXYGEN CONTENT 60%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.4	0.78	0.62	0.22%
5	-2.4	0.90	0.83	0.28%
6	-1.9	0.96	0.93	0.33%
9	-0.4	1.14	1.23	0.48%
12	1.1	1.32	1.51	0.67%
15	2.7	1.50	1.78	0.83%

OXYGEN CONTENT 61%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.6	0.79	0.64	0.22%
5	-2.6	0.92	0.86	0.33%
6	-2.1	0.98	0.96	0.33%
9	-0.6	1.16	1.26	0.48%
12	0.9	1.34	1.54	0.67%
15	2.3	1.53	1.81	2.22%

OXYGEN CONTENT 62%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.7	0.81	0.67	0.28%
5	-2.8	0.93	0.88	0.33%
6	-2.3	0.99	0.99	0.33%
9	-0.9	1.18	1.29	0.48%
12	0.6	1.36	1.57	0.67%
15	2.0	1.55	1.85	2.22%

OXYGEN CONTENT 63%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-3.9	0.82	0.69	0.28%
5	-3.0	0.95	0.91	0.33%
6	-2.5	1.01	1.01	0.42%
9	-1.1	1.20	1.32	0.48%
12	0.3	1.39	1.61	0.67%
15	1.7	1.58	1.89	2.22%

OXYGEN CONTENT 64%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.1	0.83	0.71	0.28%
5	-3.2	0.96	0.93	0.33%
6	-2.7	1.02	1.04	0.42%
9	-1.3	1.22	1.35	0.55%
12	0.0	1.41	1.64	0.83%
15	1.4	1.60	1.92	2.22%

OXYGEN CONTENT 65%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.2	0.85	0.73	0.28%
5	-3.4	0.98	0.96	0.33%
6	-2.9	1.04	1.07	0.42%
9	-1.6	1.24	1.38	0.55%
12	-0.3	1.43	1.67	0.83%

OXYGEN CONTENT 66%				
Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.4	0.86	0.76	0.28%
5	-3.5	0.99	0.98	0.33%
6	-3.1	1.06	1.09	0.42%
9	-1.8	1.25	1.41	0.55%
12	-0.5	1.45	1.71	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 67%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.6	0.87	0.78	0.28%
5	-3.7	1.01	1.01	0.42%
6	-3.3	1.07	1.12	0.42%
9	-2.1	1.27	1.44	0.55%
12	-0.8	1.47	1.74	0.83%

OXYGEN CONTENT 68%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.7	0.88	0.80	0.28%
5	-3.9	1.02	1.03	0.42%
6	-3.5	1.09	1.14	0.42%
9	-2.3	1.29	1.46	0.55%
12	-1.1	1.50	1.77	0.83%

OXYGEN CONTENT 69%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-4.9	0.90	0.83	0.28%
5	-4.1	1.04	1.06	0.42%
6	-3.7	1.10	1.17	0.42%
9	-2.5	1.31	1.49	0.67%
12	-1.4	1.52	1.80	2.22%

OXYGEN CONTENT 70%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.1	0.91	0.85	0.33%
5	-4.3	1.05	1.08	0.42%
6	-3.9	1.12	1.20	0.48%
9	-2.8	1.33	1.52	0.67%
12	-1.6	1.54	1.84	2.22%

OXYGEN CONTENT 71%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.2	0.92	0.87	0.33%
5	-4.5	1.07	1.11	0.42%
6	-4.1	1.14	1.22	0.48%
9	-3.0	1.35	1.55	0.67%
12	-1.9	1.56	1.87	2.22%

OXYGEN CONTENT 72%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.4	0.94	0.89	0.33%
5	-4.7	1.08	1.13	0.42%
6	-4.3	1.15	1.25	0.48%
9	-3.3	1.37	1.58	0.67%
12	-2.2	1.58	1.90	2.22%

OXYGEN CONTENT 73%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.6	0.95	0.91	0.33%
5	-4.9	1.10	1.16	0.42%
6	-4.5	1.17	1.27	0.48%
9	-3.5	1.39	1.61	0.67%
12	-2.5	1.61	1.93	2.22%

OXYGEN CONTENT 74%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.7	0.96	0.94	0.33%
5	-5.1	1.11	1.18	0.48%
6	-4.7	1.18	1.30	0.48%
9	-3.7	1.41	1.64	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 75%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-5.9	0.98	0.96	0.33%
5	-5.3	1.13	1.20	0.48%
6	-4.9	1.20	1.32	0.48%
9	-4.0	1.43	1.67	0.83%

OXYGEN CONTENT 76%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.1	0.99	0.98	0.33%
5	-5.4	1.14	1.23	0.48%
6	-5.1	1.22	1.35	0.55%
9	-4.2	1.44	1.69	0.83%

OXYGEN CONTENT 77%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.2	1.00	1.00	0.33%
5	-5.6	1.16	1.25	0.48%
6	-5.3	1.23	1.37	0.55%
9	-4.5	1.46	1.72	0.83%

OXYGEN CONTENT 78%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.4	1.01	1.02	0.42%
5	-5.8	1.17	1.27	0.48%
6	-5.5	1.25	1.40	0.55%
9	-4.7	1.48	1.75	0.83%

OXYGEN CONTENT 79%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.5	1.03	1.04	0.42%
5	-6.0	1.19	1.30	0.48%
6	-5.7	1.26	1.42	0.55%
9	-4.9	1.50	1.78	0.83%

OXYGEN CONTENT 80%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.7	1.04	1.07	0.42%
5	-6.2	1.20	1.32	0.48%
6	-5.9	1.28	1.45	0.55%
9	-5.2	1.52	1.81	2.22%

OXYGEN CONTENT 81%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-6.9	1.05	1.09	0.42%
5	-6.4	1.22	1.35	0.55%
6	-6.2	1.30	1.47	0.55%
9	-5.4	1.54	1.84	2.22%

OXYGEN CONTENT 82%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.0	1.07	1.11	0.42%
5	-6.6	1.23	1.37	0.55%
6	-6.4	1.31	1.50	0.67%
9	-5.7	1.56	1.86	2.22%

OXYGEN CONTENT 83%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.2	1.08	1.13	0.42%
5	-6.8	1.25	1.39	0.55%
6	-6.6	1.33	1.52	0.67%
9	-5.9	1.58	1.89	2.22%

OXYGEN CONTENT 84%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.4	1.09	1.15	0.42%
5	-7.0	1.26	1.42	0.55%
6	-6.8	1.34	1.54	0.67%
9	-6.2	1.60	1.92	2.22%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 85%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.5	1.11	1.17	0.48%
5	-7.2	1.28	1.44	0.55%
6	-7.0	1.36	1.57	0.67%
9	-6.4	1.62	1.95	2.22%

OXYGEN CONTENT 86%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.7	1.12	1.19	0.48%
5	-7.3	1.29	1.46	0.55%
6	-7.2	1.38	1.59	0.67%

OXYGEN CONTENT 87%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-7.9	1.13	1.21	0.48%
5	-7.5	1.31	1.48	0.67%
6	-7.4	1.39	1.62	0.67%

OXYGEN CONTENT 88%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.0	1.14	1.23	0.48%
5	-7.7	1.32	1.51	0.67%
6	-7.6	1.41	1.64	0.83%

OXYGEN CONTENT 89%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.2	1.16	1.25	0.48%
5	-7.9	1.34	1.53	0.67%
6	-7.8	1.42	1.66	0.83%

OXYGEN CONTENT 90%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.4	1.17	1.27	0.48%
5	-8.1	1.35	1.55	0.67%
6	-8.0	1.44	1.69	0.83%

OXYGEN CONTENT 91%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.5	1.18	1.30	0.48%
5	-8.3	1.37	1.58	0.67%
6	-8.2	1.46	1.71	0.83%

OXYGEN CONTENT 92%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.7	1.20	1.32	0.48%
5	-8.5	1.38	1.60	0.67%
6	-8.4	1.47	1.74	0.83%

OXYGEN CONTENT 93%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-8.8	1.21	1.34	0.55%
5	-8.7	1.40	1.62	0.67%
6	-8.6	1.49	1.76	0.83%

OXYGEN CONTENT 94%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.0	1.22	1.36	0.55%
5	-8.9	1.41	1.64	0.83%
6	-8.8	1.50	1.78	0.83%

EQUIVALENT AIR DEPTH AND OXYGEN MANAGEMENT TABLE – METRIC (continued)

OXYGEN CONTENT 95%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.2	1.24	1.38	0.55%
5	-9.1	1.43	1.67	0.83%
6	-9.0	1.52	1.81	2.22%

OXYGEN CONTENT 96%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.3	1.25	1.40	0.55%
5	-9.2	1.44	1.69	0.83%
6	-9.2	1.54	1.83	2.22%

OXYGEN CONTENT 97%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.5	1.26	1.42	0.55%
5	-9.4	1.46	1.71	0.83%
6	-9.4	1.55	1.85	2.22%

OXYGEN CONTENT 98%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.7	1.27	1.44	0.55%
5	-9.6	1.47	1.73	0.83%
6	-9.6	1.57	1.88	2.22%

OXYGEN CONTENT 99%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-9.8	1.29	1.46	0.55%
5	-9.8	1.49	1.76	0.83
6	-9.8	1.58	1.90	2.22%

OXYGEN CONTENT 100%

Depth	EAD	PO_2	OTU / Min	CNS% Min
3	-10.0	1.30	1.48	0.55%
5	-10.0	1.50	1.78	0.83%
6	-10.0	1.60	1.92	2.22%

Tec Deep Diver Statement of Understanding and Learning Agreement

This statement informs you of hazards, risks and your responsibilities for participating in the DSAT Tec Deep Diver course. Your signature acknowledges that you accept these risks and responsibilities.

I, ____, understand that as a DSAT Tec Deep Diver (or Apprentice Tec Diver) I should:

1. Maintain good mental and physical health for diving. Refrain from being under the influence of alcohol or drugs when tec diving. Stay proficient in diving skills, in particular, the skills required for certification as a DSAT Tec Deep Diver (or Apprentice Tec Diver).
2. Engage only in diving activities consistent with my training and experience.
3. Use complete, well-maintained, reliable equipment for which I have appropriate training.
4. Adhere to the team diving concept, but always be prepared to complete any dive without the assistance of a team mate. Although self sufficient, the responsible tec diver dives as part of a team and adheres to team diving principles.
5. Maintain the proper attitude during training in which I agree to:
   - Follow the instructor's directions and dive plans strictly, and not to separate from the instructor or my dive team.
   - Refrain from tec diving outside this course until I am fully qualified and certified.
   - Accept the risk for this type of diving, and for specific risks unique to each dive environment, and to immediately notify the instructor if this risk becomes intolerable for me.
   - Recognize the desirability of carrying diver accident insurance that covers tec diving (if available in my local area), and recognize that my instructor may require me to have it.
6. Demonstrate self sufficiency – plan each dive as though it will be necessary to make the dive and handle all emergencies alone.
7. Demonstrate discipline and an attitude consistent with responsible technical diving – I will not cut corners, bend the rules, disregard dive plans, omit safety equipment or exceed the limits of my training.
8. Obtain an orientation when diving in new environments.
9. Know, obey and respect local diving laws and regulations including private land owner relations.
10. Accept the responsibility for my personal safety, while accepting and acknowledging the risks, and demands tec diving imposes.
11. Stay informed on and dive according to the state of the art in diving, tec diving, dive rescue, dive equipment and other influences on my safety as a tec diver.
12. Accept that technical scuba diving has many general risks and hazards that either don't exist in recreational diving, or aren't as severe, including:
    - No direct access to the surface in an emergency due to decompression requirements.
    - Hypoxia/hyperoxia resulting from switching to the wrong gas, which can lead to drowning.
    - Narcosis, which can lead to poor judgment/bad decisions that can cause an accident.
    - DCS due to improper gas analysis, missed deco stops, loss of deco gas and individual susceptibility. DCS can cause permanent injury or death.
    - Omitted procedures due to task loading, which can lead to accidents, DCS, air embolism, oxygen toxicity, or drowning.
    - Drowning or air embolism due to BCD failure.
    - Extensive equipment requirements with redundant configurations, which can lead to ergonomic complexity, increased risk of error and a physical burden.
13. I accept that a significant difference exists between recreational scuba diving and technical scuba diving, and that in technical scuba diving, even if you do everything right, there is still a higher inherent potential for an accident leading to permanent injury or death.

I have read the above statements and have had any questions answered to my satisfaction. I understand the importance and purpose of these practices and recognize they are for my own safety and well being.

I understand that failing to ahere to the above statements will put me at risk, and may be grounds for my dismissal from the Tec Deep Diver course. I acknowledge that the instructor is not permitted to and will not certify me if I don't meet all course performance requirements or if I demonstrate an attitude or behavior incompatible with responsible technical diving practices.

_______________________________________ Participant Signature

_______________________ Day/Month/Year

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