Technical Rescue Course

Team Blue Immersion
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PADI TecRec Distinctive
Technical Rescue Diver Course

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Course Overview

Introduction

This section includes recommendations on how to use this guide, an overview of course philosophy and goals, a flow chart to show you how course components and materials work together for success, and ways you can organize and integrate student diver knowledge development and skills training.

How to Use this Guide

This guide speaks to you, the PADI Technical Rescue Diver Instructor. You will use it to help your the students become outstanding technical rescue divers.

The guide contains four sections. The first details the standards for the course. The second section contains knowledge development modules. The third section details the practical applications that will take the knowledge they gained in the previous section into the real world. The final section is where everything comes together. It takes place in the open water and involves five dives over three days.

All required standards, learning objectives, activities, and performance requirements specific to the PADI Recreational Twin Set Diver course appear in **boldface** print. **The boldface assists you in easily identifying those requirements that you must adhere to when you conduct the course**. Items not in boldface print are recommendations for your information and consideration

General course standards applicable to all PADI courses are located in the General Standards and Procedures section of your PADI *Instructor Manual*.

Course Philosophy and Goals

With the recent explosive growth in popularity of technical diving, divers with a greater variety of backgrounds and experience levels are entering the sport. Technical diving is no longer the preserve of the seasoned open circuit diver.

In addition, in search of the elusive wreck or undiscovered cave, technical divers are venturing farther and farther afield. These dive sites are often many hours away from emergency first aid and decompression facilities.

Both these factors increase the overall risk to the technical diving community creating the need for a new level of rescue diver training.

The technical rescue diver is trained to operate in a highly stressed rescue environment. Her water skills are honed to perfection. She has the knowledge and skill to extinguish sparks that set off error chains before they become a problem. She is a valued for her ability to cultivate a culture of safety.

The goal of the course is to develop the skills taught during the Rescue Diver course to a very high level and relate them specifically to the hazards, equipment and techniques encountered during technical diving in open water. In addition, this course will teach technical divers how to conduct technical diving risk assessments and how to prepare effective emergency plans.

Course Integration with Other PADI and TecRec Course Material

To develop the high degree of knowledge development required of a technical rescue diver, we will use information contained in the Knowledge Development handout found in the Appendix, PADI Rescue Diver Manual and Tec Deep Diver manual.

Key Standards

Student Diver Prerequisites

Certified as a Tec 45 diver or qualifying certification from another training organization. For the purposes of this level, a qualifying technical certification is one that qualifies the student to make decompression dives to 45 metres/145 feet using air, EANx and oxygen using open circuit scuba equipment. 18 years old, 100 logged dives (20 deeper than 18 metres/60 feet using EANx, at least 15 deeper than 30 metres/100 feet (with or without EANx).

PADI Oxygen Provider Speciality or provide a qualifying certification from another training organization. For this course, a qualifying certification is proof of training in oxygen equipment maintenance and providing oxygen to victims in all conditions.

18 years of age

Diver Certification Qualifications

Technical Rescue and Safety Diver Certification

Instructor Qualifications

PADI Tec Deep Instructor

Technical Rescue and Safety Diver Distinctive Speciality Instructor

PADI Oxygen Provider Speciality Instructor

Assistant Qualifications

Renewed PADI Divemaster or higher level PADI Member

PADI Tec 45 diver or higher level DSAT diver

Have made at least 10 decompression dives to 40 metres/130 feet deeper not including training dives made for certification in the Tec Diver course

Training Dive Depth

Dives 1 to 5 -- min 10 meters max 18 meters non-decompression

Maximum Ratio

4:1 (use Certified Assistants with Technical Rescue Diver qualifications to increase the ratio with 2:1) max ratio 6:1 on all open water dives

Minimum Time

3 days

Equipment Student and Instructor

Double cylinders of at least 12 l/70 cf each, with isolator manifold.

The isolator manifold is not required for divers using sidemount configuration.

Divers known to have a very low gas consumption rate may, at the instructor's discretion, use lower capacity cylinders than specified here, provided the diverwill have ample gas to assist a team mate in a gas sharing emergency.

Primary and secondary regulators for back mounted double manifolds, one with two metre/seven foot hose for air sharing and one with SPG. Note: In sidemount configuration, one regulator must have the two metre/seven foot hose, and both regulators must have an SPG.

Stage/decompression cylinder(s) (1 for Tec 45, 2 for Tec 50) with regulator and SPG, with proper labels/markings.

Tec diving BCD(s) and harness (backmount or sidemount)

Two multigas enriched air capable dive computers, or one multigas enriched air computer and a back up single gas computer with dive tables, or one single gas enriched air computer and a backup timer and depth gauge with dive tables.

Exposure suit appropriate for environment and dive duration (if students will use dry suits, they should be trained/experienced in their use in recreational diving prior to using them for tec training or diving).

Argon dry suit inflation system (as needed for environment)

Weight system (if needed). Note: Students and staff should weight for the contingency of decompressing with near-empty primary cylinders and empty or absent stage/deco cylinders.

Jon line (as needed for environment)

Inflatable signal tube, whistle and/or other visual and audible surface signalling devices. Note that a sausage type DSMB may double for the inflatable signal tube.

Reel and lift bag (bright yellow preferred) or DSMB. A suitable DSMB has ufficient buoyancy to help steady a diver during a drifting decompression, and is unlikely to spill when deployed from the underwater.

Knife/cutting device and back up Slate

Back up mask (optional)

Compass

Lights (optional – as required for dive environment)

Backup buoyancy control – the student must have a reliable means for controlling buoyancy and maintaining decompression stops in midwater with a failed primary BCD. This is usually accomplished with a backup BCD (double wings) or, when using light weight cylinders, the use of a dry suit is permitted.

Instructor Materials

1. ***PADI Instructor Manual***
2. ***PADI Guide to Teaching***
3. ***PADI Tec Deep Diver Manual***
4. **Tec RecTechnical Rescue Distinctive Speciality Outline**
5. **Medical Statement for Technical Diving**
6. **Liability Release and Express Assumption of Risk for Technical Diving**
7. **Tec Diver Statement of Understanding and Learning Agreement**
8. **Technical Rescue Diver Knowledge Review**
9. **Technical Rescue Diver Knowledge Review Answers**

Student Materials

1. **Technical Rescue Diver Handout**
2. ***PADI Rescue Diver Manual***
3. **The *Tec Deep Diver Manual***

Course Flow Options

The sections of this outline must be completed in order with the exception that dives one and two may precede the knowledge development and the two practical applications. The student must complete the knowledge review prior to commencing the practical applications. The student must complete the practical application prior to dive three.

Course Content

Welcome and Staff and Student Introductions

- **Upgrade technical diver rescue skills to a level required by the higher risks and greater complexity of technical diving**
- **Teach technical divers how to comprehensive diver and dive site risk assessments**
- **Provide technical divers with advanced emergency procedures necessitated by diving in remote locations**

Course overview

- Knowledge Development
- The Practical Applications
- In Water Skill Development – open water with increasing levels of simulated stress
    - Dives 1 and 2 diver rescue skill refresher and development
    - Dives 3, 4 and 5 rescue scenarios

Certification

Students are issued the TecRec Technical Rescue Diver Distinctive Speciality certification card upon successful completion of the course.

What Certification Recognizes:

1. You have mastered the highest level of self and team mate technical rescue skills
2. You are qualified to prepare technical diver and dive site risk assessments and emergency plans
3. You are able to recognize and remediate the most likely risk factors in open water, open circuit technical diving

Class Requirements

1. Cost of course (be sure to explain all costs)
2. Equipment needs
3. Required materials
4. Attendance requirements
5. Level of knowledge mastery and skill development required for certification

How the Students Will Gain Mastery of Knowledge Reviews

1. Homework involving studying assigned parts of the *Tec Deep Diver Manual* and *PADI Rescue Diver Manual*
2. In class discussions
3. Knowledge Reviews

Administration.- complete paperwork

1. **Enrolment forms**
2. **Standard Safe Diving Practices Statement of Understanding,**
3. **Medical Statement**
4. **Liability Release and Express Assumption of Risk For Technical Rescue Distinctive Speciality**

Content Delivery

The Causes and Prevention of the Most Common Technical Diving Accidents

Introduction

Open circuit, open water technical diving accidents are rare.

Precise information is not currently available as there is no one depository for information about open water technical diving accidents. This technical rescue diver manual bases its analysis on the available general information and on an extrapolation of the risks inherent in the general open water technical diving environment.

CNS toxicity and DCS are highlighted as major risks by all the major technical diving education organizations.

Obviously, no one intends to get injured while diving. What causes divers to choose the wrong gas or get bent?

1. Diver overconfidence is a forerunner to many diving accidents.

2. Over stressed divers are more likely to be involved in accidents

3. Sloppy or improper dive planning often leads to dive incidents

- Technical rescue diving starts with accident prevention. Most accidents are preceded by chains of events, called error chains, which in many cases makes an accident inevitable. That's where we start.

<u>Anticipating and Avoiding Error Chains</u>

Student Objectives:

How to identify error chains

Why it's easier to prevent chains from starting than stop them

How to stop error chains from starting

In technical diving like most human endeavours, most accidents can be traced back to an origin - often an event that seemed insignificant at the time.

Origins such as a skipped buddy check or a short-cut with dive planning can seem quite harmless initially, but, these acts have the capacity to create chains of events that lead to an emergency.

It is far easier to eliminate origins than it is to interrupt the chain once it gets going. For example, skipping a buoyancy check at the surface could lead to an overconsumption of air during the dive, which could have significant consequences if the diver or dive team losses some of their deco cylinders.

The loss of deco gas may have occurred because of a separate error chain. But combined, the two chains create a potentially deadly situation.

Spotting these acts requires constant vigilance of your own and team mate behaviour.

Clearly, any breach of safety procedures has the potential to start a chain.

A short cut can be an origin with the added characteristic of also shortening the error chain itself.

Develop the practice of logging all observed minor infractions of proper diving procedures.

Suggest that the team hold periodic informal safety planning meetings independent of dive briefs and debriefs. This is your opportunity to bring up your logged minor infractions.

- For example, you note a team mate skipping a personal equipment check after assembly. Naturally you should privately point this out to the diver at the time. But, also bring it up without naming the diver during a safety planning meeting.

Encourage team members to maintain their logs and make the meetings opportunities for general discussions on dive team safety

Interrupting error chains that could lead to threatening situations requires a great deal of dive experience. You must "have seen it before" to see it again.

Encourage a culture of safety

Diver Overconfidence Leading to Reckless Behaviour

Recognition

Overconfidence is an attitude coloring the diver's perception of risk in relation to the diver's ability to overcome the perceived risk.

Every human is susceptible to becoming overconfident. In many pursuits it is an admired trait. However, in technical diving overconfidence can be substantial risk factor.

Achieving technical diving certification is the highlight of many diving careers. Often, accompanying the sense of accomplishment is the belief that traditional diving rules no longer apply. Moreover, it takes a certain amount of bravado to take up technical diving in the first place.

Indicators of overconfidence include:

Student objectives:

Know how to spot dangerous overconfidence

Know the steps to minimize the risks of overconfidence

How to counsel the overconfident diver

1. Improvised or non-standard equipment set up
2. Inattention during dive briefings
3. Skipped buddy checks
4. Rudimentary or nonchalant bubble checks / decent checks
5. Disregard for maximum depth limits or oxygen limits
6. General bravado or bragging personality
7. Overstating experience level

You should recognize that the diver may not even be aware that his overconfiden~~t~~ce may lead to reckless and possibly dangerous behaviour.

Look for divers framing past risky behaviour in terms of having little likelihood of producing a negative result. Statements such as "I knew I was diving beyond the gas's maximum depth. But, you know there is a big safety margin built into the rules."

Listen for divers expressing an optimism bias. For example, "Yes sure, I once dived with a broken secondary inflator. It wasn't a very challenging dive."

A reluctance to be involved in dive planning or logistics is also often indicative of overconfidence.

Prevention of harm

Step one is to do a self examination for signs of overconfidence. Set a positive example of thoroughness in safety checks and adherence to technical diving rules. Your example of "cautious confidence" may motivate other members of the team to follow suit.

Step two is to always stress proper diving and safety procedures during briefings and debriefings without singling anyone out. Use "hypothetical examples" to illustrate what could happen if procedures are not followed.

Step three is to be always on the lookout for team members exhibiting the signs of overconfidence. The diver may be cautious in one activity say equipment setup but reckless in another like depths.

Step four is to seek advice. Once an overconfident diver situation is recognized, seek advice from the senior diver or team leader as to the best way to proceed.

Step five is to intervene. Providing uninvited counselling is always very challenging. This is especially true with overconfident individuals. However, as the whole team's safety rests with each member's contribution, someone must do it.

Step six is to be sensitive to the diver's feelings. Basic rule in evaluating a team mate's problematic performance is to do it in private. Avoid using blame or negative words. Just like any briefing, point out positive first and then remind the diver of areas in which improvement can be made.

Step seven is to act on behalf of the whole team's safety. Ultimately, given that the whole team's safety hangs with each and every member, you or the senior diver on the team may have to ask the over-confident diver to leave the team.

Excessive Diver Stress

At almost the opposite end of the spectrum from dangerous overconfidence, excessive diver stress can also be a forerunner to accidents. Refer students to pages 19 to 24 and 66 to 69 in their *PADI Rescue Diver Manual*

Why Stress?

A major part of the technical rescue diver's role is to anticipate and eliminate the potential sources of stress during a dive or dive series. The very presence of a technical rescue diver on the team should relieve some stress.

In spite of your best efforts, a certain amount of stress will always be present in technical diving. Greater depths and decompression requirements create physical and mental strain.

Identifying and understanding the sources of stress as well as being able to mentor divers about stress management are important capacities of the technical rescue diver.

Stress is a powerful feeling that rises due to both internal and external sources. Stressful feelings may result from physical and/or psychological stimuli.

Learning objectives:

How to recognize stress in yourself and your team mates

How to assist team mates dealing with stress

How to associate feelings with their external causes

How to become a mentor

Recognizing Stress in a Diver

- An important step in dealing with stress is recognizing the feeling when it arises. Symptoms include:

  1. Expressed feelings of frustration and/or uncertainty
  2. Muscular tension
  3. Increased perspiration and heart rate
  4. Increased respiration
  5. Narrowing awareness illustrated by having difficulty assembling their rig
  6. General physical and emotional discomfort
  7. Distinct change in personality – the quiet diver becomes loud; the extroverted diver becomes self-contained

Helping Team Mates Deal with Stress:

Teaching divers how to recognize the rising of stressful feelings by helping them compare their current feelings with those which arise in non-stressful situations

Illustrating the connection between the stressful feeling and their probable causes both physical and psychological

- Associate these feelings with their actual cause minimizing risk that the diver may create imaginary causes. For example, feelings of frustration may relate to a personal problem completely unrelated to the planned dive. Muscular tension could be the result of a recent tough gym workout. Question the diver about her feelings and about the causes that are unrelated to the upcoming dive.

Work at gaining the respect and- trust and respect of dive team members

  - So they come to you for advice on dealing with stressful feelings
  - So that you can approach divers and discuss your observations of stressful signs
  - So that you have the respect and authority to call or hold dives
  - So that you can mentor divers helping them learn

- So you can show them how to identify the initial onset of stressful feelings

To this point we have discussed Error Chains, Diver Overconfidence and Diver Stress. Now we will relate these topics to the two principle risks in technical diving, names CNS Toxicity and DCS.

Breathing the Wrong Gas - Central Nervous System (CNS)

Student objectives

Know why CNS toxicity occurs and its symptoms and consequences

Know that a reaction to breathing a gas beyond its safe limits is impossible to predict

Learn how to prevent a toxic reaction to a mix

Know what to do if you experience CNS toxicity symptoms

Learn how to respond to an underwater convulsing diver

Oxygen Toxicity

The risks associated with CNS oxygen toxicity cannot be overstated. It is the number one cause of death of technical divers. Refer students to pages 47 to 48 and page 124 of the *TecDeep Manual*. Appendix P45 of the Technical *Rescue Diver Course Outline*.

Causation

Although there has been considerable research on oxygen toxicity, little is known about its physiological causes.

Individuals vary in their response differently to levels of oxygen exposure by time and environment. Tolerances vary so dramatically that it is impossible to predict an individual's toxicity.

High levels of oxygen exposure (P02) create the risk of epileptic like seizures, which can occur without notice. The seizures are often very violent and impact the whole body.

These seizures often result in rejection of the victim's second stage regulator creating a high probability of drowning.

Theoretically, long term exposure to high concentrations of oxygen can make the diver more susceptible to seizure. Follow CNS Clock and OTU guidelines.

Because the onset of seizures can come without warning, divers must not rely on the VENTID diagnostic acronym as predictive of an event.

If a VENTID symptom should appear, the diver must immediately switch to lower oxygen gas. Divers must avoid quickly ascending as the exertion exaggerates the production of carbon dioxide increasing the risk of seizure.

Individuals differ in their susceptibility to convulsions and how the convulsions present. Some individuals present full body convulsions moving in and out of consciousness much like an epileptic fit. While others present localized movements and remain conscious throughout.

A critical point, which cannot be over stated, is that it is impossible to project future tolerance by previous experiences. Research indicates that very large variations can appear in the same individual over a period as short as three weeks. (Donald, K. (1992) Oxygen and the Diver. Worcs. Great Britain: the SPA Ltd.)

Toxic reactions relate to exposure pressure and time. A PO2 of 1.4 is tolerable by the vast majority of divers for the working part of the dive for up to 150 minutes. A PO2 of 1.6 is tolerable for decompressing for a total of 45 minutes. (both above examples take into account that you don't have any further oxygen exposure beyond the given minutes at the given oxygen partial pressure.. Going beyond these limits puts the diver at increasing risk of oxygen toxicity symptoms including convulsions. (Donald, K. (1992) Oxygen and the Diver, Worcs. Great Brittan: the SPA Ltd.)

Prevention

Risky behaviour (discussed above) of "this won't happen to me" mind set is a significant factor leading to CNS toxicity incidents. The technical rescue diver must be vigilant in observing team mate behaviour suggestive of breathing a gas below its safe depth. For example, any non-trimix dive below the safe limit of air (55 meters) is clearly indicative of a reckless mindset.

The general rule is if possible never take a gas deeper then you can safely breathe it. But, often that is not feasible due to risk of loss of the gas.

Thus, the technical rescue diver must ensure that all team members are completely up to date on NOTOX procedures. The NOTOX must be discussed in every briefing and practices during every dive.

It is the special responsibility of the technical rescue diver to perform an examination of each team member's gas switch to ensure that appropriate gas is breathed and thus in effect sign-off on the switch.

The technical rescue diver must ensure that team mates have adequate hovering skills and have team members practice "team mate breathing wrong gas drill" as well as the "unconscious diver on the bottom" drill prior to any advanced dive expedition.

Another factor is the diver's overall exposure to oxygen. Be extra conservative as you or any of the dive team approaches a CNS clock exceeding 75%. As divers begin to build up their CNS levels, consider using a PO2 toxicity limit of 1.3 and 1.5 for the working part of the dive and decompression respectively.

Another factor is exertion (perhaps artificially caused by stress) and the consequential build-up of carbon dioxide. Be extra conservative if the dive subjected you or your team mates to hard work or fast swim. If you felt winded it would be wise to switch later in the ascent than planned.

Caution your team mates about the consumption of alcohol or the taking some drugs prior to diving as they may increase the risk of convulsion.

Finally, dehydration and fatigue are considered risk factors for a increased sensitivity to O2 toxicity. Worth to note is that pseudoephedrine is suspected of increasing the likelihood of CNS Oxygen Toxicity.

"Air breaks". You should switch to the gas with the lowest, but safest, oxygen content every 10 minutes for 3 minutes. The "air breaks" is been known to not only give the body a rest from the high oxygen levels in the breathing gas and thereby reducing irritation of the lungs, but actually by increasing the effectiveness of the total decompression by avoiding the body to go into vasoconstriction that might occur during high oxygen exposures. At this point we are not included the air breaks as a part of our decompression time, but there are suggestions that because "air breaks" tend to make the total decompression more effective due to less likelihood of vasoconstriction we might in the future see new recommendations stating that you can include the break into the total decompression time.

Emergency response self rescue

Refer students to pages 124 of the *Tec Deep Diver Manual.*

If you experience CNS symptoms (remember VENTID), immediately switch to your back gas (lowest oxygen). If using back gas, make an immediate but slow and controlled ascent. The extra exertion of a forced rapid ascent will increase carbon dioxide in your lungs, which will exasperate the toxicity symptoms

Check your depth and reconfirm the gas you're breathing as you may have descended below the blend's maximum depth.

Stay on your back gas for at least 15 minutes after your CNS symptoms have subsided.

As your susceptibility to CNS toxicity may be higher than normal, be very conservative switching to richer blends. Ascend well above the blend's ideal level. Do not count the time on back gas as decompression time if you're on an accelerated decompression.

On no stop dives, stay on back gas, ascend immediately and abort the dive.

Follow the post symptoms conservative approach throughout the remainder of your decompression. If you must skip stops to ascend, extend shallower stops to reduce your DCS risk.

Team mate rescue - breathing wrong gas

Refer students to pages 124 to 126 of the *Tec Deep Diver Manual.* Technical Rescue Appendix page 45 for an Action plan when dealing with a victim of Oxygen toxicity.

If you note a team mate breathing gas while deeper than its maximum immediately pull the second stage from your team mate's mouth and provide your long hose. This may appear extreme, but oxygen convulsions can come quickly, suddenly and without warning. Do not waste time trying to signal.

Your team mate stays on back gas (own or yours) until sorting out the problem and finding the correct cylinder.

Team mate convulses underwater

Obviously, drowning is the concern when a team mate convulses underwater.

Try to hold the second stage in the diver's mouth to minimize the risk of drowning.

Check your depth and switch to back gas if you and the team mate descend to avoid increasing your risk of convolution.

How you best help your team mate has many variables depending on your decompression status – you may risk getting bent if you take the victim to the surface yourself. You'll have to quickly consider these options:

- If you have support divers on the surface, you can signal them and have them meet you at a decompression stop. The support diver can take over and get your team mate to the surface. This is the best option.
- It's worth noting that when taking a convulsing diver to the surface (you or the support divers), it is generally recommended if the regulator is in the victim's mouth, to hold it in place and wait for the convulsion to cease, then bring the victim up, maintaining a neutral head position that allows air to escape from the airway.
- If the victim has already spit out the regulator, it is generally recommended to avoid spending time trying to replace it.

- It’s generally recommended that rescuers don’t drop the victim’s weights before reaching the surface, because if they do, they may lose control of the victim and put themselves at risk.

- If you’re decompressing with high oxygen EANx or pure oxygen for conservatism with a single gas table or computer, your risk of getting DCS may be minimal even with deco time remaining. The higher the oxygen above what the table/computer thinks you’re using, and the longer you’ve deco’d, the less the risk.

- If risk is high, and you have a long deco ahead and have not started, and there’s assistance at surface, you may just need to let the victim surface for topside personnel help. If there’s no help at the surface, this may still be the best you can do.

Learning objectives

Learn the four primary risk factors for DCS

How best to combat DCS risk factors

What to do in case you become separated from your deco gas

How to predict an increase of DCS risk due to environmental factors and what to do about them

How dive profiles factor in DCS

The important diver predispositions to DCS both immediate and inherent

How to diagnose DCS both pain only and neurological

Decompression Sickness

So little is known about decompression sickness that every time we dive we are in a sense part of an experiment testing the decompression models currently in use. This is especially true when we dive beyond recreational limits. However, one thing is certain, missing required decompression stops or ascending too quickly greatly increases the risk of DCS. P246 to 249 of the *Tec Deep Diver Manual.*Appendix P43 of the Technical *Rescue Diver Course Outline.*

Causation

It is generally accepted in technical diving that there are four primary risk factors involved in decompression sickness incidents: failure to complete the required decompression obligation; environmental factors; dive profiles; and, diver predisposition.

Failure to complete the required decompression obligations

A primary tenant of technical diving is the absolute necessity of planning for and conducting required decompression stops.

There are two primary reasons why divers miss decompression stops namely, limited gas supply and loss of buoyancy due to lack of experience using a drysuit.

Not having enough gas to adequately decompress can arise because of poor dive planning and/or execution or by losing decompression gas cylinders.

<u>Build in safeguards to ensure proper planning and dive execution</u>

Make dive planning a team responsibility and a team event. Have each team member sign off on the plan to create personal investment in it.

As part of the planning process develop contingency plans to account for lost or inadequate decompression gas.

Be extra vigilant and engage your team mates and get their affirmation to follow the dive as planned.

During the debriefing, ensure that you compliment the team on following the plan and to remind the team if a diversion occurred.

How to develop neurological baselines for team mates

How to conduct neurological tests in the field

How to treat victim of decompression sickness

<u>Ensure adequacy and security of deco cylinders by never staging a cylinder when you are not absolutely positive that you can find them when you need them.</u>

That means never navigate away from a stage point without reeling out.

Never stage cylinders where other divers may interfere with them.

Always, check to make sure that every team member pressurizes their regulator and turns off the valve prior to staging.

<u>Know what to do in the unlikely event that you become separated from your decompression cylinders?</u>

Naturally, your dive plan should have accounted for this contingency by ensuring that you could have complete the dive on your back gas. So, either follow your computer's back gas decompression plan or decompress according to your back gas only contingency tables.

However, if due to an emergency you and/or your team mates do not have sufficient back gas to complete decompression:

- Obviously, the first option is to share gas with team mates assuming that some of the team's reserves were maintained or to use gas provided by a support diver.
- The second option is to send up an emergency DSMB with a slate requesting the support diver to deliver the necessary decompression gases for the diving team to be able to complete all required decompression stops.

- The final option is to send a diver up to get surface support to send gas down or in the extreme case to retrieve the cylinders and descend and complete decompression according to the emergency delayed/omitted decompression schedule.

Environmental factors which may increase the risk of DCS

Water temperature – Immersion in cold water reduces peripheral blood flow, slowing both on-gassing and off-gassing. Watch for ending a highly energetic mission (increases on-gassing) with a cold decompression.

When diving in cold water extend the decompression and avoid inmersion in hot water (bath, shower & etc) post dive. Suddenly increasing body temperature (through taking a hot shower or a hot bath) can expand gas bubbles in the blood stream which form when ascending from a dive, and can increase the risk of decompression sickness.

Currents – Except for drift diving, diving in currents involves greater exertion. Factor in the added exertion into your decompression planning especially in situations involving cold water.

Dive profiles

Deeper dives lead to greater Nitrogen loading in the tissues which are slow to release gas during decompression and during surface intervals. Thus, repetitive deep diving increases risks.

Multiple assents as in saw tooth diving allows for greater bubble formation and entrapment in slow diffusing tissues. This leads to a build up of bubbles with the consequential slow down of off-gassing.

Although there is no scientific evidence that reverse profiles increase the risk of DCS, it is generally accepted that, as in multiple ascents, reverse profile diving increases bubble formation and entrapment in the slow tissues.

Technical Divers using trimix as bottom gas might increase their risk of DCS due to Isobaric Counter Diffusion (ICD) which is caused due to the fact that nitrogen diffuses into tissues 2.65 times slower than helium, but is about 4.5 times more soluble. Switching between gas mixtures that have very different fractions of nitrogen and helium can result in "fast" tissues (those tissues that have a good blood supply) actually increasing their total inert gas loading. This is often found to provoke inner ear decompression sickness, as the ear seems particularly sensitive to this effect. ICD is also a concern when breathing a helium based mix and using a dry-suit, due to the body tissues fast absorption of helium, This is the reason why helium based gas should never be used for inflation of the dry-suit. See Appendix P48 of the *Technical Rescue Diver Outline* for more information about Isobaric Counter Diffusion (ICD).

Physical: Predisposition immediate

Dehydration

Almost all victims of DCS are dehydrated. So ensure an adequate supply of safe drinking water and promote drinking water among team members. Encourage limiting alcohol consumption as alcohol consumption causes dehydration.

Heavy exercise during or immediately after diving.

Particularly cardio vascular exercise just before, during or after diving increases the speed at which bubbles are released increasing the risk of DCS

Physical: Predisposition inherent

Fitness

- Studies have consistently shown that because of fat's higher tissue Nitrogen absorption rate, having a high body mass index have a significantly higher risk of decompression sickness.
- Encourage all team members to maintain a proper body weight fitness level. Consider setting up team gym nights or other fitness encouraging events and activities.

PFO Patent foramen ovule

- Estimated that up to 30% of the adult population have open PFOS. In most of these cases the pressure between the left and right atriums press a skin flap effectively blocking the ovule.
- This skin flap may be dislodged in a reversal of pressure as when the diver coughs or vomits. During events of high blood stream bubble formation, bubbles may pass from the venous side to the arterial side and eventually reach the brain.
- PFOs are clinically difficult to diagnosis

Diagnosing DCS

- The most common symptom is joint pain in the upper extremities.
  - The pain can be a little twitching or niggling to a feeling of a knife twisting in the joint. The pain usually subsides over a period of time.
  - However, due to the risk that the diver may develop more severe symptoms later, it is prudent to provide emergency oxygen until all pain subsides.

- Another common symptom is manifested in the skin. It can slight ~~as~~ itching to a visible skin rash. The diver should be observed to ensure that more severe symptoms do not manifest.

- Another symptom is extreme fatigue. Again, similar to the non-life threatening symptoms described above, it is indicative of DCS and the diver should be monitored to ensure that the fatigue is not followed by more severe symptoms.

- It is quite common for bubbles to occur on the venous side of the blood system, which usually is not problematic.

  - Problems do occur if the bubbles become large or numerous enough to interfere with the transfer of gases between the capillaries and ovules in the lungs.

  - Symptoms include chest pain, difficulty breathing and raspy coughing.

  - Oxygen treatment and medical evacuation is advised.

- The most extreme cases of DCS occur when bubbles enter the arterial blood system, which creates the potential of the bubbles being carried to sensitive body regions such as the brain and spinal cord.

- Decompression sickness could manifest itself on both side of the body, however most common is either upper or lower body.

- Reference to pages 148 to 151 *PADI Rescue Diver Manual* and pages 124 to 126 of the *Tec Deep Diver Manual*.

Neurological exams

- Prior to a dive or dive series, conduct a neurological exam on each team member and record the results to serve as a base line for comparison with an exam conducted post dive.

- Below is an example neurological exam, which can form the basis of the exams that you conduct. The key is consistency between the baseline and field application.

- There is an advantage of using an established neurological exam the scores of which can be transmitted to and understood by professional medical personal.

- An example is the Rapid Neurological Exam Checklist handout.

- Mental Status:

1. Alertness - Does patient seem to be aware of what is going on and able to communicate appropriately
2. Orientation - Does patient know who they are, how old are they, where they are, what date/day it is, what have they been doing
3. Memory* - Ask patient to remember three objects then later in the exam ask the patient to recall the objects
4. Calculation* - Have patient count backwards from 100 by sevens

- Cranial Nerves:

1. Eyes - Can patient see, is vision normal, is eye movement normal
2. Hearing - Can patient hear equally in both ears, is hearing normal
3. Smell - Can patient smell (coffee, peppermint, etc.)
4. Facial Muscles - Is the face equal in muscle tone and control, have patient smile
5. Tongue - Can patient control tongue movement, it should stick straight out
6. Gag Reflex - Does the "Adam's Apple" move when patient swallows
7. Facial Sensation - Can patient feel light touch equally on both sides of their face
8. Shoulders - Can patient raise their shoulders equally against resistance
9. Muscle Strength against resistance (using 0-5 scale):

- Arms:

1. Lift arms away from side
2. Push arms towards side
3. Pull forearm towards upper arm
4. Push forearm away from upper arm
5. Lift wrist up
6. Push wrist down
7. Squeeze examiners finger

8. Pull fingers apart*
9. Squeeze fingers together*

- Legs:

1. Lift legs up
2. Push legs down
3. Pull legs apart*
4. Push legs together*
5. Pull lower leg towards upper leg
6. Push lower leg away from upper leg
7. Push feet away from legs
8. Pull feet towards legs

- Sensory (have patient close eyes while checking sensory perception):

1. Light Touch* - Can patient feel light touch equally on both sides of the body
2. Sharp/Dull - Can patient distinguish between a sharp or dull object on both sides of the body
3. Hot/Cold* - Can patient distinguish between a hot or cold object on both sides of the body
4. Coordination* (on any test requiring a patient to stand make sure someone is there to support them):
5. Have the patient touch their nose with their index finger of each hand with eyes shut
6. Have the patient rapidly slap one hand on the palm of the other, alternating palm up and then palm down - test both sides
7. Have the patient walk heel to toe in a straight line - forwards and backwards
8. While standing, have the patient touch the heel of one foot to the knee of the opposite leg, and while maintaining this contact, have them run the heel down the shin to the ankle - test each leg
9. With eyes closed, have the patient stand with feet together and arms extended to the front, palms up

Dive and Site Risk Assessment

Have students review the Emergency Procedures sections of *Tec Deep Diver Manual* pages: 60 to 64; 123 to 130; 162 to 167; 202 to 210; 230 to 231; and, 246 to 250.

- Risk assessment and avoidance is at the heart of dive planning, which should precede every technical dive.
- Although serious accidents are rare, they do happen. Moreover, in almost every technical dive something goes wrong, but we accommodate or remediate to minimize the related potential harm. That is what good divers do.

1. Effective dive planning reduces many risks and eliminates others
2. Sets up emergency procedures and contingency plans
3. Prevents error chains from continuing once started
4. Making sure that multiple risks do not combine to engineer an unmanageable situation

Learning objectives:

How to conduct dive risk assessments

The importance of establishing specific dive parameters

The three risk categories and how best to minimize them

How to use a "**G**ood **D**ivers **M**ain **O**bjective **I**s **T**o **L**ive" to plan dives

- Establish dive parameters – dive timing, depth, mission duration, gas sufficiency, maximum deco obligations and etc
- Three categories of risk that we must account for in our risk assessment planning
    - Inherent risk – dive site location, deco ceilings, currents, visibility, temperature, dangerous sea life & etc
    - Diver related – experience, fitness, compatibility with team mates & etc
    - Manufactured risks – gases, tank labelling, equipment adequacy and compatibility
- A good starting point is a focused us of a "**G**ood **D**iver's **M**ain **O**bjective **I**s **T**o **L**ive"

Refer Students to pages 103 to 107 in their *DSAT Tec Deep Diver* manual

Good – G – Gas management

Diver's – D – Decompression

Main – M – Mission

Objective – O – Oxygen

Is – I – Inert gas narcosis

To – T – Thermal exposure

Live – L – Logistics

Practical Applications

Conducting Dive Site Risk Assessments and Dive Planning

Students prepare a skills/experience assessment using each other as proposed team mate and a dive site and dive series description provided by the instructor. Using this assessment, students prepare personal remedial skill development plans and team skills practice plans.

Learning objectives:

Give students hands on experience

1. Analyzing a dive site for risk and preparing dive plans that accommodate or minimize the risks

2. Preparing an emergency plan and managing an emergency based on their plan

3. Conducting a neurological exam on a team mate both on land and in the water

Students assess the risks of an actual dive expedition site and develop a risk reduction plan and brief the dive team using the plan.

Emergency Planning and Management

Assessing emergency equipment requirements for specific technical diving site scenarios

Working in teams, have students conduct an emergency inventory for a remote dive site. Provide challenging features such as remoteness from emergency services, absence of portable water, strong current.

Setting up specific emergency and evacuation protocols for different site characteristics

Working in teams, have students plan emergency protocols and evacuation plans for the remote site you detailed in the previous example. This should include planning for medium term oxygen treatment.

Administering Neurological Examinations In and Out of the Water

Have students create baselines for team mates and then conduct neurological tests both on land and during a simulated deco stop.

Using the neurological examination and procedures that you have

Training Dives

Skill Development in the open water

The purpose of skill development in training dives one and two is to upgrade student self rescue skills. The instructor may introduce the skills listed under each dive in any order. Try to increase the pace of introduction and the apparent urgency of the emergency situations as the dive progresses to introduce a controlled amount of stress in the students. Introduce emergency situations are your discretion and have students repeat exercises until mastered.

The purpose of dives three, four and five is to introduce simulated real life scenarios for student response. Try to make the scenarios as realistic as possible and involve the whole team. Ensure that each student has an opportunity to play each role of surface support, victim and assisting team mates.

Training Dive Standards

Order and Sequencing of Skills – Skills assigned to a particular dive must be mastered prior to the commencement of the next training dive. Remediate with additional dives as necessary. The instructor may change the order of skills within a dive and add skills and emergency situations that have been mastered in previous dives.

Depths - All Technical Rescue Training Dives are non-decompression dives and are conducted in open water. (See Section One, Course Standards for definitions.) The minimum depth for Dives One and Two is 10 metres/30 feet and the maximum depth is 18 metres/54 feet. The minimum depth for Dives Three, Four and Five is 15 meters/50 feet and the maximum depth is 27 meters/90 feet.

Ratios – 4 students to 1 instructor, with 2 more students permitted with a certified assistant to a maximum of 6. (See your Tec Deep Diver Manual for specific requirements necessary to qualify as a certified assistant.) These are maximums – reduce ratios as necessary to accommodate student characteristics and environmental/logistical variables.

Equipment - Students and instructor must be equipped as described in Section One of this Manual with accommodation for environmental needs. This includes two decompression cylinders.

Gases

Air or Enriched Air within 1.4 ppo2.

General Scenario Considerations

1. Make scenarios as realistic as possible, within reasonable logistical requirements
2. Adapt scenarios to accommodate the environment and class size. Have student divers carry out scenarios as teams or as individuals
3. Use certified assistants also certified as TecRec Technical Rescue Divers to close gaps in scenarios, such as role-playing, EMS Operators, other persons and victims.
4. Have typical equipment (first aid and oxygen kits) available, but allow divers to set up and place equipment
5. Repeat scenarios as necessary to build confidence, improve rescuer performance and allow everyone to play different roles.

Dive One – Self Rescue (Open Water)

Learning objectives

Upgrade student rescue diver skills

Teach students special techniques for dealing with technical diving emergencies

Predive briefing - Students set up their rigs, but do not don exposure suits at this point. In teams, the divers inspect each rig for correct setup, ample gas, proper cylinder labels, etc.

Dive site overview - Depth, temperature, entry/exit points, note worthy features, etc.

Dive overview – Describe the exercises the divers will be performing and the fact that a measured amount of stress will be added to simulate real world emergency scenarios.

Predive check

Have teammates perform a pre-dive safety check with assigned problems.

Entry

Have divers enter the water in a manner appropriate for the environment

Bubble check

Have team enter water and examine and on the surface team dunks manifold below surface.

Descent check

Have students descend several meters below the surface and inspect each other for bubbles and correct gas selection. Students should respond to problems and use appropriate signals. Assign problems of loose gear and possibly gas selection. Perform an S-drill as part of the descent check and equipment matching.

Malfunctioning BCD

From a neutral buoyant position, deflate or overinflate student primary BCD signalling failure. Students will demonstrate disconnecting the LPI of the overinflating BCD and releasing air at the same time switching to their backup BCD inflating it appropriately. Students will demonstrate a deflating BCD by switching to their backup BCD inflating it appropriately. The principle objective is to maintain neutral buoyancy during the exercise.

Entanglement

Attach a thin line around student's leg simulating an entanglment. Students using their cutting tool cut the entangling line to free themselves. Students replace cutting tool in holder and continue the dive.

No mask swim with staging and retrieving stage/deco cylinders

Have students remove mask and stage two cylinders at two separate locations. Student swims at least nine meters and then returns and retrieves and correctly dons the two cylinders.

Free flow while neutrally buoyant

While student is neutrally buoyant, simulate a regulator free flow by purging students purge button. Student responds by breathing from free flowing regulator and closing the correct valve. The student then switches to operating regulator and opens closed valve. Student should remain within one half meter of their starting depth.

Manifold isolator shutdown within 30 seconds while neutrally buoyant

While student is neutrally buoyant, simulate a leak by pressing purge button of your regulator behind student's head so student hears air flow off to one side or another. Student shuts down the appropriate valve, switching second stages if necessary.

No Mask out of air swim and done staged cylinders

Student acting as donor supplies air to a teammate. Student removes mask. Teammate signals out of air. Student provides long hose and swims for at least ten meters maintaining appropriate contact with teammate sharing air. Students locate, done and switch to staged cylinders.

Emergency lift bag deployment (with attached slates for communication with surface support)

Upon the instructor signalling an emergency requiring surface support, students retrieve the emergency bag/DSMB (yellow or green) and reel and attach slate with the required request for support.

Simulated emergencies

Tell students that depending upon time, gas supplies, etc, throughout the dive you may surprise them with impromptu emergencies via hand signals or your slate that they must respond to appropriately.

Dive Two – Team Mate Rescue (Open Water)

Predive briefing - Students set up their rigs, but do not don exposure suits at this point. In teams, the divers inspect each rig for correct setup, ample gas, proper cylinder labels, etc.

Dive site overview - Depth, temperature, entry/exit points, note worthy features, etc.

Dive overview – Describe the exercises the divers will be performing and the fact that a measured amount of stress will be added to simulate real world emergency scenarios.

Learning objectives

Upgrade student rescue diver skills rescuing another diver

Teach students special techniques for dealing with technical diving emergencies when assisting a team mate

Predive check

Have team mates perform a predive safety check with assigned problems. Observe and evaluate teammate's response to problem. Students must correctly perform the check correcting all problems. Ideally, students should perform the safety check applying the standard procedure:

Entry

Have divers enter the water in a manner appropriate for the environment

Bubble check

Have team enter water and examine and on the surface team dunks manifold below surface. Teammates check each other for bubbles leaks.

Team enters the water and each dunks. Check each other for bubble leaks at first stage/ valve, in manifold, etc

Descent check

Have students descend several meters below the surface and inspect each other for bubbles and correct gas selection. Students should respond to problems and use appropriate signals. Assign problems of loose gear and possibly gas selection. Perform an S-drill as part of the descent check and equipment matching.

No Mask out of air swim

Student acting as donor supplies air to a teammate. Students remove masks. Teammate signals out of air. Student provides long hose and swims for ten meters maintaining appropriate contact with teammate sharing air.

Out of back gas, NOTOX switch

Assign out of back gas diver at a NOTOX switch point. Have perform gas switch using donors long hose as back gas resource.

Surfacing the unresponsive diver

Assign victim and rescuer roles. Rescuer secures regulator in victim's mouth and achieves neutral buoyancy for self and victim. Rescuer swims victim to ascent point and surfaces victim.

Simulated emergencies

Tell students that depending upon time, gas supplies, etc, throughout the dive you may surprise them with impromptu emergencies via hand signals or your slate that they must respond to appropriately.

Learning objectives

Help students master the skills involved with sharing back gas and decompression gas during a decompression stop

Dive Three – Rescue Scenario One Out of Gas during Deco (Open Water)

Predive briefing - Students set up their rigs, but do not don exposure suits at this point. In teams, the divers inspect each rig for correct setup, ample gas, proper cylinder labels, etc.

Dive site overview - Depth, temperature, entry/exit points, note worthy features, etc.

Dive overview – Describe the exercises the divers will be performing and the fact that a measured amount of stress will be added to simulate real world emergency scenarios.

Predive check

Have team mates perform a predive safety check with assigned problems.

Entry

Have divers enter the water in a manner appropriate for the environment

Bubble check

Have team enter water and examine and on the surface team dunks manifold below surface.

Descent check

Have students descend several meters below the surface and inspect each other for bubbles and correct gas selection. Students should respond to problems and use appropriate signals. Assign problems of loose gear and possibly gas selection. Perform an S-drill as part of the descent check and equipment matching.

Rescue Scenario One: Out of air technical diver during deco stop

Assign donor and out of air roles and have students react to a situation where one or two divers are low on air during a deco stop, using the emergency lift bag to get attention from on the boat who will react appropriately and supply the diver/divers with gas

Learning objectives

Teach students special techniques for dealing with a convulsing diver underwater and surfacing the diver once the diver looses consciousness

Simulated emergencies

Tell students that depending upon time, gas supplies, Technical Rescue Divers etc, throughout the dive you may surprise them with impromptu emergencies via hand signals or your slate that they must respond to appropriately.

Dive Four – Scenario Two Convulsing Diver Under Water (Open Water)

Predive briefing - Students set up their rigs, but do not don exposure suits at this point. In teams, the divers inspect each rig for correct setup, ample gas, proper cylinder labels, etc.

Dive site overview - Depth, temperature, entry/exit points, note worthy features, etc.

Dive overview – Describe the exercises the divers will be performing and the fact that a measured amount of stress will be added to simulate real world emergency scenarios.

Predive check

Have team mates perform a predive safety check with assigned problems.

Entry

Have divers enter the water in a manner appropriate for the environment

Bubble check

Have team enter water and examine and on the surface team dunks manifold below surface.

Descent check

Have students descend several meters below the surface and inspect each other for bubbles and correct gas selection. Students should respond to problems and use appropriate signals. Assign problems of loose gear and possibly gas selection. Perform an S-drill as part of the descent check and equipment matching.

Rescue Scenario Two: Convulsing Diver at the bottom requiring full egress

Assign rescuer and victim roles. Provide slate to rescuer describing the victim's signs and their progression. Student rescuer assesses situation and responds appropriately. The instructor also provides a slate with the student's simulated decompression requirements. The student surfaces the victim and tows victim to egress point following appropriate rescue procedures. The skill ends after the student egresses the diver and provides appropriate first aid.

Note: issues to be considered

What gas do you supply the convulsing victim?

How much decompression can you safely skip?

How do you manage your other team mates in assisting with rescue?

How do you communicate with and manage surface support during ascent?

If you choose to skip all your decompression stops on your rescue ascent, would you re-descend and if so how would you calculate your remedial decompression schedule?

Given the surface resources you have at hand, how would you treat the victim and organize evacuation and provide medium term emergency care?

Learning objectives

Working as a team, have divers using both in water and boat support search for a missing diver

Once found, students surface and egress the unresponsive diver

Dive Five – Rescue Scenario Three Missing Team Mate (Open Water)

Predive briefing - Students set up their rigs, but do not don exposure suits at this point. In teams, the divers inspect each rig for correct setup, ample gas, proper cylinder labels, etc.

Dive site overview - Depth, temperature, entry/exit points, note worthy features, etc.

Dive overview – Describe the exercises the divers will be performing and the fact that a measured amount of stress will be added to simulate real world emergency scenarios.

Predive check

Have team mates perform a predive safety check with assigned problems.

Entry

Have divers enter the water in a manner appropriate for the environment

Bubble check

Have team enter water and examine and on the surface team dunks manifold below surface.

Descent check

Have students descend several meters below the surface and inspect each other for bubbles and correct gas selection. Students should respond to problems and use appropriate signals. Assign problems of loose gear and possibly gas selection. Perform an S-drill as part of the descent check and equipment matching.

Scenario

Inform students that a team mate(s) is/are missing. Students should independently follow their missing diver protocol. At the end of the protocol, the students should commence a search for the diver(s). Once found unconscious, the student rescuers should surface the divers (s) and tow them while removing their technical gear to the egress point.

Appendix

Technical Rescue Diver Study Assignments and Knowledge Review Questions

Technical Rescue Diver Study Assignments

Technical Rescue Diver Knowledge Review Questions

Please complete this review 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. What is the purpose of the Technical Rescue Diver Course?

2. What is an error chain? What is the usual starting point?

3. How can you prevent error chain originators from occurring?

4. How do you stop error chains once they commence

5. What are four common risks leading to injury to technical divers?

6. Why is diver overconfidence a risk?

7. How do you recognize an overconfident diver?

8. How would you recognize dangerous overconfidence in yourself?

9. What are some of the ways of dealing with an overconfident diver?

10. What must you avoid in dealing with the overconfident diver?

11. What factors increase the risk of CNS toxicity in an individual?

12. Explain why you should not rely on VENTID symptoms as indicative of an impending seizure.

13. Should you use past diving experience to tell you how deep you can dive with a gas? Why not?

14. What are the eight preventative measures that you can take to avoid any team member from breathing the wrong gas at depth?

15. What should you do if you experience CNS symptoms? What must you avoid?

16. Describe what you should do if you observe a team mate breathing the wrong gas?

17. What should you do if you encounter an unconscious diver underwater?

18. What role could a support diver play?

19. How would you balance your decompression obligations with the need to get an unconscious diver to the surface?

20. What are the four main causes of decompression sickness for technical divers?

21. How would you build in safe guards to ensure that team members have sufficient gas to complete decompression obligations?

22. What are your options if you become separated from your decompression cases?

23. Name the two most important environmental factors in DCS.

24. What two immediate physical factors affect the risk of DCS?

25. List the inherent predispositions that increase the risk of DCS.

26. What are the signs and symptoms of DCS?

27. How would you diagnose DCS in a team mate?

28. Describe the steps you would take to conduct a neurological examination.

29. What is the first aid treatment for DCS victims?

30. How do you recognize excessive diver stress? And, what should you do about it?

31.

32.

Rapid Neurological Exam Checklist

Rapid Neurological Exam Checklist

(Note any results which are Not Normal)

- **Mental Status:**
  - Alertness - Does patient seem to be aware of what is going on and able to communicate appropriately
  - Orientation - Does patient know who they are, how old are they, where they are, what date/day it is, what have they been doing
  - Memory - Ask patient to remember an three objects then later in the exam ask the patient to recall the objects
  - Calculation - Have patient count backwards from 100 by sevens
- **Cranial Nerves:**
  - Eyes - Can patient see, is vision normal, is eye movement normal
  - Hearing - Can patient hear equally in both ears, is hearing normal
  - Smell - Can patient smell (coffee, peppermint, etc.)
  - Facial Muscles - Is the face equal in muscle tone and control, have patient smile
  - Tongue - Can patient control tongue movement, it should stick straight out
  - Gag Reflex - Does the "Adam's Apple" move when patient swallows
  - Facial Sensation - Can patient feel light touch equally on both sides of their face
  - Shoulders - Can patient raise their shoulders equally against resistance
- **Muscle Strength against resistance (use 0-5 scale):**
  - Arms:
    - Lift arms away from side
    - Push arms towards side
    - Pull forearm towards upper arm
    - Push forearm away from upper arm
    - Lift wrist up
    - Push wrist down
    - Squeeze examiners finger
    - Pull fingers apart
    - Squeeze fingers together
  - Legs:
    - Lift legs up
    - Push legs down
    - Pull legs apart
    - Push legs together
    - Pull lower leg towards upper leg
    - Push lower leg away from upper leg
    - Push feet away from legs
    - Pull feet towards legs
- **Sensory (have patient close eyes while checking sensory perception):**
  - Light Touch - Can patient feel light touch equally on both sides of the body
  - Sharp/Dull - Can patient distinguish between a sharp or dull object on both sides of the body
  - Hot/Cold - Can patient distinguish between a hot or cold object on both sides of the body
- **Coordination (on any test requiring a patient to stand make sure someone is there to support them):**
  - Have the patient touch their nose with their index finger of each hand with eyes shut
  - Have the patient rapidly slap one hand on the palm of the other, alternating palm up and then palm down - test both sides
  - Have the patient walk heel to toe in a straight line - forwards and backwards
  - While standing, have the patient touches the heel of one foot to the knee of the opposite leg, and while maintaining this contact, have them run the heel down the shin to the ankle - test each leg
  - With eyes closed, have the patient stand with feet together and arms extended to the front, palms up

Inert gases and why some are to *nobel* to be used

During a technical instructor class I got the question about some fairly exotic gases that is not used by technical divers. Questions like why don't we use Hydrogen or Neon in our breathing mix instead of Helium? We discussed this topic when I realized that there is little information about inert gases (nobel gases). So I thought it might be useful to summaries the different gases out there and talk a little about each and one of them to clarify some of the questions that came up during our discussion. As a Technical Rescue Diver it's important that you have a fundamental understanding why we are using the gases we do.

A safe breathing gas has three essential features:

- it must contain sufficient oxygen to support the life, consciousness and work rate of the breather.
- it must not contain harmful gases. Carbon monoxide and carbon dioxide are common poisons in breathing gases. There are many others.
- it must not become toxic when being breathed at high pressure such as when underwater. Oxygen and nitrogen are examples of gases that become toxic under pressure

First some definitions:

- *Air* is a mixture of several gases that are invisible and odourless. It consists of about 78% nitrogen, 21% oxygen, and less than 1% of argon, carbon dioxide, and other gases — as well as varying amounts of water vapour. Adults breathe in about 10-20 cubic metres of air every day. That's about 20,000 breaths. Children breathe almost twice that amount because they are smaller, and their respiratory systems are still maturing. Being cheap and simple to use, it is the most common diving gas
- Pure *oxygen* is mainly used to speed the shallow decompression stops at the end of a technical dive. The disadvantage of breathing pure oxygen is that by exposing yourself with *too much of the good stuff*, could lead to pulmonary oxygen toxicity. To reduce this risk we take breaks from breathing pure o2 every 10-20 minutes of exposure. By taking "air breaks" the latest research show that we actually make our decompression more effective by reducing the effects of vasoconstriction. Todays dive planning does not include "air-breaks" into the decompression time but we might see due to future research that the advantage of reduced vasoconstriction might actually make the overall decompression so much more effective that we can include the "air breaks" into our decompression time so that the break from breathing pure oxygen will not lead to an extended stop at 6 meters and shallower. Some technical divers prefer to use 80% oxygen for the shallower stop during the decompression so that the "air break" becomes obsolete.
- Normoxic trimix: Oxygen content is 21%, *same as air has.*
- Hypoxic trimix: Oxygen content is *less* than 21%.
- *Nitrox* is a mixture of oxygen and air, and generally refers to mixtures which are more than 21% oxygen. It can be used as a tool to accelerate in-water decompression stops or to decrease the risk of decompression sickness and thus prolong a dive. Nitrox is a common mix today among recreational divers and technical divers, but in the early 90s some diving magazines and diving organizations referred to Nitrox as the "death gas".

- *Trimix* is a mixture of oxygen, nitrogen and helium and is often used at depth in technical diving and commercial diving instead of air to reduce nitrogen narcosis and to avoid the dangers of oxygen toxicity.
- Triox is a mixture of Oxygen, helium and nitrogen and where the oxygen content is higher than 21%. Triox are commonly used as decompression gas after a deep trimix dive.
- *Heliox* is a mixture of oxygen and helium and is often used in the deep phase of a commercial deep dive to eliminate nitrogen narcosis. Heliox is not suitable for technical divers because of an increased risk of HPNS (Helium Pressure Nervous Syndrome) which could lead to tremors while diving deeper than 120 meters. By mixing some nitrogen in the mixture (Trimix) you reduce the amount of Helium and therefore reduce the risk of HPNS.
- *Hydreliox* is a mixture of oxygen, helium, and hydrogen and is used for dives below 130 metres in commercial diving.
- *Hydrox*, a gas mixture of hydrogen and oxygen is used as a breathing gas in very deep diving.
- *Neox* (also called neonox) is a mixture of oxygen and neon sometimes employed for in deep commercial diving. It is rarely used due to its cost. Also, DCS symptoms produced by neon ("neox bends") have a poor reputation, being widely reported to be more severe than those produced by an exactly equivalent dive-table and mix with helium.

Correlation of Narcotic Potency of Inert Gases

Gas	Molecular Weight	Solubility in Lipid	Relative Narcotic Potency
Helium (He)	4	0.015	0.2 (least narcotic)
Neon (Ne)	20	0.019	0.3
Nitrogen (N_2)	28	0.067	1.0
Oxygen (O_2)	32	0.110	1.7
Argon (Ar)	40	0.140	2.3
Krypton (Kr)	83.7	0.430	2.5
Carbon Dioxide (CO_2)	44	1.340	20.0
Xenon (Xe)	131.3	1.700	25.6 (most narcotic)

Hydrogen

Advantage	Disadvantage
Least narcotic of all gases	Hydrogen used together with oxygen (*hydrox*), is very explosive, if the percentage of oxygen is more than 4-5%. For this reason it's not possible to breathe this mix above 30 meters to avoid hypoxia.

Helium

Advantage	Disadvantage
Reduced narcotic effect	HPNS (Helium Pressure Nervous Syndrome), expensive, can’t be used as an insulator in the drysuit, ICD (Isobaric Counter Diffusion)

Neon

Advantage	Disadvantage
Reduced narcotic effect	Very expensive (more than 50 times more expensive than helium), could lead to difficult decompression sickness and is more complex to recompress than helium.

Argon

Advantage	Disadvantage
Great dry suit inflation gas due to it's good thermal characteristics and relatively cheap price.	Very narcotic gas

Krypton

Advantage	Disadvantage
None known advantage	Create dizziness and is very expensive

Xenon

Advantage	Disadvantage
In theory a very good thermal insulator	Very narcotic and very expensive

Convulsions – Action plan

Signs and symptom: **(CON) VENTID**

Phases during actual convulsions:

Remember that **signs and symptoms of Hyperoxia** are highly variable. Susceptibility **varies** between individuals and for the same person from one day to another. A grand mal convulsion occurs normally in three phases:

- The **'Tonic' Phase**: a phase of body rigidity which last normally for one minute. Its dangerous to initiate an ascent during the Tonic Phase due to **spasm** of the glottis (shutting up of the glottis, meaning passage of the wingpipe, which creates a feeling of strangulations and difficulty in breathing) and respiratory muscles that might result **inadequate exhalation** and could **provoke pulmonary barotrauma**.

- The **'Clonic'** Phase in which the victim undergoes **true convulsions**. Length varies.

- The **'Resting'** Phase in which the victim resume breathing.

Convulsing Diver

Approach from behind the victim and establish physical contact by holding regulator in the mouth of the victim. If the diver does not have a regulator in the mouth don't put the regulator back due to the risk of water introduction/drowning . Instead use the regulators mouth piece externally to seal the mouth in the hopes that the diver upon breathing will inhale 'air' rather than water.

Control depth by using the LPI of the convulsing diver (drysuit and/or wing). Grab any object available to control depth. *Second rescue diver send yellow emergency bag to alert surface crew*. Wait max 2 minutes for the Tonic and Clonic period (convulsing phase) to stop.

After convulsion, approx 2 minutes (Tonic and Clonic phase)

- Diver start to breath. *Action:* Ascent and complete any required deco stops with the diver. Keep airways open. Stay close to diver.

- Diver does Not start to breath. *Action:* immediately start ascending. If the diver doesn't start to breath upon reaching your first decompression stop then send him up by inflating his wing and by 'dropping' the victims deco tanks. Attach the victim to the Emergency SMB line, if entanglement can be avoided, to avoid the victim drifting away. If possible contact any divers in the water that could help to assist during the ascent. Only send the diver to the surface alone if you have decompression obligations and if you have surface crew available.
  If no surface crew, judge the situation depending on your deco obligation. There are two options available beyond sending the victim alone if there is no surface crew present. These two options are highly dangerous for the rescuer and could lead to serious injury and possible death.
- Option 1: Ascend with the victim and call for help and descend within one minute. Re-descend to your first stop depth and follow planned stop times. Extend all stops starting from 9 meters as long as possible.

- Option 2: Ascend with the victim and call for help. Tow the victim to the shore or boat if you can. If no DCS symptoms manifest itselves spend max 5 minutes at the surface. However if DSC symptoms do occur descend immediately. Start with compression on shore or boat if possible. Re-descend to your first stop depth and follow planned stop times. Extend all stops shallower from 9 meters as long as possible.

Isobaric Counter Diffusion

A simple visualization for

Tolerable breathing gas changes of percentage Nitrogen during a Trimix dives

Type III DCS caused ICD is predominantly a problem when carrying out Trimix dives that are deep enough and long enough to generate formal decompression stops that require the use of a hypoxic Trimix. (i.e.:- formal deco stops deeper than 40meters/130ft)

Assumption: - Formal decompression can be carried out safely only when the TOTAL quantity of dissolved gas from all partial pressures of inert gases in a tissue is less than the tissues overall M-value. This is a new way of looking at gas absorption and release, but it is very important to view decompression of Trimix in this manner to get an understanding of what's going on with ICD.

Now, the quantity of a dissolved gas for a saturated medium is equal to:-

Current saturation pressure x solubility factor in the medium. For lipid tissues, the solubility factors of Nitrogen and Helium are as follows

Solubility of Helium=0.015

Solubility of Nitrogen=0.067 (approx 4.5 times more soluble)

(Solubility factors from 'Scuba Diving in Safety & Health by Chris Duer, MD) ISBN 0-9614638-0-5)

Note that the solubility of Nitrogen in lipid tissues is more than 4 times that of Helium

But, the diffusability (the speed the gas goes into and out of solution) will also come into the dynamics of the overall model. The speed of diffusivity of Helium is 2.65 times faster than Nitrogen.

So lets look at the aiming conditions by examining a gas switch 'at the ascent ceiling' from Trimix 20/25 to Nitrox32 at 40 meters deep

These are the partial pressure 'aiming points' for the tissues in (bars)

Depth	**Ambient pressure**	**Trimix 20/25**		**Nitrox32**	
		pp-n2	**pp-He**	**pp-N2**	**pp-He**
40m/130ft	5 bars	2.75	1.25	3.4	0

Although the sudden jump in ppN2 appears small, one must remember that the 'aiming point' for the TOTAL amount of dissolved gas in the tissue is actual as follows

Before switch

(2.75x0.067) + (1.25x0.015) =0.18425+0.01875 =0.203 (i)

Immediately after the switch

(3.4x0.067) + (0) =0.2278+0 =0.2278 higher than (i) !!!

Hence the effect of switching to Nitrox from Trimix has the effect of INCREASING the overall gas loading within the tissue since the loss of 25%helium is more than taken up by the increase in Nitrogen from 55 to 68%(13%). This is not a good thing if you happen to be sitting on the ascent ceiling at this time. This will cause an immediate fast tissue DCS Hit.

Conclusions

1. Switching from Trimix20/25 to Nitrox32 at 40meters aims to increase gas overall tissue gas loading
2. Since the solubility of Nitrogen is 4.5 times more soluble than Helium, Nitrogen should never increase more than (say) 1/5 the reduction of Helium content to keep the aiming point for the dissolved gases the same

Example 'Buffer gas switching rule of 1/5ths '

Necessary if carrying out formal deco on intermediate Trimix

% Helium Gas reduction	Permissible %Nitrogen Increase
10	2
20	4
30	6
40	8
50	10
60	12
70	14
80	16
90	18

This would suggest that if you were carrying out formal decompression stops on intermediate Trimix at the time:-

A Switch fromTrimix20/25 to Nitrox 32 is NOT OK since Nitrogen jumps from 55 to 68% (a 13% jump), where the rule of 5^{th} suggests a maximum allowable increase in %Nitrogen for a 25% drop in Helium of only 5%.

However, A switch from Trimix 20/25/55 to Trimix 32/8/60 would likely be tolerated.

(Oxygen/Helium/Nitrogen)

I have no idea if this gas switching ICD avoidance algorithm is a true and thorough explanation for the effects that take place in ultra deep Trimix dives, but it's predictions successfully avoid all the historical ICD cases that I had data for, It took into account the differing solubility's of helium and Nitrogen, and successfully predicted Mark Ellyatt's Gas choices and Helitrox decompression schedule for his 313meter Open circuit Trimix plunge a couple of years a go.

This dive represented the first successful use of ICD avoidance in an Open Circuit scuba dive to these depths by calculating the gas percentage change tolerable. Also, it was the first time that the diver carrying out a Trimix plunge to these depths didn't spend his last 6 hours of deco puking on every breath. A desirable result..

The only other successful ICD avoidance technique I am aware of was used by late Sheck Exley' by using 'phased in switching of Trimix to Nitrox'. The technique is explained thoroughly in is book 'Cavern Measureless to Man' ISBN 0-939748-33-9 published by Cave Books 1994. I'll give you Sheck's ICD avoidance technique here for reference. Sadly, although Sheck is no longer with us, he plainly had an unusually good instinctive feel for what was going on in his body with regards to mixed gas effects ad how to avoid them. Sheck realized that ICD was predominantly fast tissue event'

'CAVERNS MEASURELESS TO MAN'

Author:- SHECK EXLEY page 259

"At 260 feet and 250 feet...

I counted sixty-second stops with my fingers, then addressed a new source of concern: Jochen and Gene's mysterious vestibular hit. At 240 feet I had to switch from breathing 50 percent helium and 40 percent nitrogen to air, which contains 79 percent nitrogen. According to their information, the abrupt increase in nitrogen could result in instant death. And all authorities predicted a sudden onset of severe narcosis.

To make the switch as gradual as possible, I took only a single breath of air from the tank we had earlier left at 240 feet, then switched back to the helium mix for two breaths. Then came two air breaths, then back to the deep mix for one inhalation. Finally I switched over to air completely, bracing myself for the severe narcosis and dreaded vestibular hit, all the while doing my best to count off the seconds required for the stop. Nothing happened, no narcosis, no sudden lapse into unconsciousness. The only thing I felt was warmer, thanks to not having to breathe helium any more. Apparently my strategy of keeping a maximum amount of nitrogen in the deep mix worked."

Sheck’s dive plan for his 1989 dive to 881ft at Nacimiento del Rio Mante in Mexico, also follows and uncanny resemblance to what we now know to be a correct decompression profile for a Trimix dive to these depths. The only thing missing in his plan was a Helitrox decompression schedule.

I’ve put a copy of Sheck's successful 1981 dive plan up on the web at for analysis purposes at http://www.scubaengineer.com/sheck_exley_mexico_dive.htm

As to the time scales and diffusion dynamics, or what percentage change of gas can be tolerated over time and at what depth? I’ll need a few weeks of uninterrupted thought t visualize it before I can hatch the math for the exponential math matrix that’s generating these effects. All I have at the moment is a feel for what’s going on. But it’s a start.

My feeling is that taking into account ICD effects during gas switches and the compensation of HPNS with huge END’s represent the two least researched problems that can afflict ultra deep Trimix divers.

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Technical Rescue Diver Handout and Study Assignment

Technical Rescue Diver Knowledge Review Answers