Chapter 43

TECHNICAL DIVING

Most recreational SCUBA divers use compressed air in a single cylinder, with a single-hose regulator, to depths up to 30-40 metres, and avoid any decompression staging obligation (although routinely a safety stop is included for dives exceeding 12 metres).

Technical diving is a term used to describe extended diving or where the gas and/or the equipment is different from the original "Aqualung" concept, which only used open circuit, compressed air. The purpose of this technical diving is to extend durations or depths. The simplest modification is the use of a different gas in the scuba cylinder. Then comes the use of several different gases, in multiple cylinders. To reduce the increasing bulk of this diving apparatus, as well as to reduce gas loss, complex rebreathing equipment can be added.

The increasingly complex equipment bestows some advantages, but with increased risks. Some industry representatives and other enthusiastic advocates have promoted this technical diving to the recreational diving community as a safer alternative, enticing others who may not be as adept. It is a more complex and more risky activity than recreational diving and requires expensive equipment and extensive training – two reasons why it appeals to the diving industry.

Most of the diving accidents and deaths which occur in recreational scuba diving, are not due to decompression sickness. Indeed the major causes include the ocean environment (Chapter 6), the stress responses on the individual (Chapter 7), equipment failure or misuse (Chapter 5 & 34) and some diving practices which are especially hazardous – exhaustion of the air supply, buoyancy problems, and failure to follow buddy diving practices (Chapter 34). Technical diving techniques do not reduce and often increase these risks.

The complexity and novelty of technical diving has attracted many established divers, mainly men. Possibly the element of danger and the *avant guarde* nature of the activity combine to offer an enticing challenge, extending diving experiences and excitement.

The technical diver, often studious and attracted to risk taking behaviour, operates on a reduced safety margin but usually with a quiet confidence in his skills and equipment.

He may have commercial interests, being involved in wreck salvage, equipment manufacture, marketing and sales, diver training, or other related activities. An appreciable number of high-profile experts in technical diving have died undertaking this activity, and their deaths have hopefully served to caution many younger and less experienced divers.

DEFINITION

1. USING GASES OTHER than COMPRESSED AIR
   e.g. OXYGEN
   NITROX, (Oxygen Enriched Air),
   HELIOX, (Helium & Oxygen)
   TRIMIX, (Helium, Nitrogen & Oxygen)
2. DECOMPRESSION DIVING
3. DEEP DIVING (> 40 metres)
4. REBREATHINGEQUIPMENT

Technical diving refers to diving in excess of the usual range for recreational scuba divers. This may involve an extension of duration at any depth, the depth itself (in excess of 30–40 metres), changing the gas mixtures to be used, or using different types of diving equipment. All these fall into the realm of technical diving.

It is important, when discussing technical diving, to specify which type, as the relative risk varies from little or no additional risk (compared with recreational diving) to a high one, such as with rebreathing equipment.

Decompression dives and deep diving using only compressed air have added risks and have already been dealt with in previous chapters.

The other risks increase as the gas mixture deviates from normal air and with increased complexity of the equipment.

Diving on 32% oxygen, 68% nitrogen instead of air in a scuba cylinder, to a maximum of 40 metres on a no-decompression conventional air profile, could possibly incur slightly less risk than a recreational scuba air dive.

THE TECHNICAL DIVE

1. DIVE PROTOCOLS, PROFILES and GAS MIXTURES
2. EQUIPMENT COMPLEXITY
3. PHYSIOLOGICAL ASSUMPTION
   — EAD / 0_2 / $C0_2$ / INERT GAS TRANSFER
4. ENVIRONMENTS
5. ACCIDENT & RESCUE IMPLICATIONS

1. DIVE PROTOCOLS, PROFILES and GAS MIXTURES

The diver attempts to select the theoretically ideal gas mixture for the ascent and descent (travel mixes), the bottom (bottom mix) and the decompression staging (usually oxygen or a high oxygen mixture).

The simplest form of technical diving has the diver breathing a mixture of 32% or 40% oxygen (O2) in nitrogen (N2). With the increased O2, there is proportionately less N2. That means less decompression obligation (and less N2 narcosis). For the same decompression risk, the dive can therefore be prolonged and this is highly desirable in some dive trips. The additional risk of oxygen toxicity must be appreciated.

Using a single O2 enriched gas mixture limits the technical diver to shallower dives than with compressed air. A series of gas mixtures in separate cylinders, with diminishing O2 percentages, allows the technical diver to reach greater depths. Substituting helium (He) for N2, either in Heliox (He/O2) or Trimix (N2/He/O2) allows the technical diver to descend further, while avoiding or reducing N2 narcosis. During ascent the changes of gas mixtures is reversed until nearing the surface, when higher O2 percentages may be breathed to expedite the elimination of inert gas (He or N2).

When there are various gas mixtures being breathed, the safe profile of the dive may be very complex and errors may be made in the choice of gas breathed. Nevertheless, using open circuit equipment and several gas mixes, dives to over 100 metres have been safely performed.

The use of rebreathing equipment enormously increases the potential hazards (see later), while attemting to control and monitor the gases breathed and thedecompression required..

2. EQUIPMENT COMPLEXITY

Technical diving involves more complex equipment for producing, supplying and delivering the various breathing gases, other than air. With an increase in the complexity of the equipment there is an associated increase in the likelihood of human error at all these 3 stages.

The handling of mixtures with higher than normal oxygen percentages implies greater risk of fire and explosions. Gas mixtures may not be as compatible as the "normal" oxygen/nitrogen mix in air, and the heat generated during compression must be appreciated. Although not common, explosions associated with high oxygen percentages are very destructive.

Problems and mistakes develop from the use of multiple gases and complex equipment:

- Mixing, labelling and transport of gas;
- Handling it at the dive site;
- Analysing the gases and confirming that they are the ones appropriate for the dive to be performed;
- Selection of appropriate gases during the dive.
- Different gases require different cylinders together with the various attachments; manifolds, O rings, contents gauges, high pressure hoses, and often, separate regulators.

Because of the added complexity of the equipment, the use of multiple gas mixtures and the increased support facilities, there are substantial initial capital outlays, operating and maintenance costs.

3. PHYSIOLOGICAL ASSUMPTIONS

There is considerable doubt regarding some of the physiological assumptions on which technical diving is based. It is claimed that the equivalent air depth (EAD) calculation can be used to determine the different influence of the gas mixture on the diver, and this has been applied to both nitrogen narcosis and decompression sickness (DCS). There is, in fact, no really good evidence that this EAD is a strictly accurate concept. Experience in highly controlled navy diving has been reassuring, and the implication is that the EAD concept is a valid approximate assumption.

Divers using O_2/N_2 mixtures decompress using tables of EAD. These calculate of the actual partial pressure of N_2 for the dive and from this calculate the depth of an air dive that has the same N_2 pressure. The diver then decompresses as if he had done an air dive to the calculated depth, the EAD.

Thus a diver breathing 40% O_2 at 30 metres (60% of 4 ATA = 2.4 ATA of N_2) has an EAD of 20 metres (80% of 3ATA = 2.4 ATA of N_2). So, after this dive to 30 metres, our diver decompresses as if he had dived to 20 metres on air.

For the same depth/duration dive, the O2 enriched diver may have less DCS risk and less N2 narcosis, but he will have more risk of O2 toxicity, than the air breathing diver. There are the physiological implications of breathing oxygen at varying partial pressures, as well as increased carbon dioxide retention with both increased oxygen diving and deep diving.

Inadequate factual information is available regarding the physiological interactions of multiple gases. The rate of inert gas transfer between the breathing gases in the lungs, the body tissues and any gas spaces (including decompression bubbles) varies both with the gas and the depth. Thus the selection of different gas mixtures is likely to influence the transfer of inert gases in many ways, far more complex than can be deduced from a simplistic formula. Anyone who doubts this should peruse one of the more sophisticated texts on such topics as nitrogen narcosis and the counter diffusion of gases.

Decompression procedures and algorithms are often unproven. Even with the vast data available on air diving to 40 metres, there are many inexplicable decompression accidents. Adding the vagaries of extended depths and durations, multiple gas mixtures and computer modelling, makes for greater uncertainty in technical diving. Technical divers should question the origin and validity of the decompression schedules they are encouraged to use. Some have had to be altered to reduce their incidence of DCS. The lack of controlled trials have caused some to compare the promoters of these decompression protocols to a pharmaceutical company marketing a drug without testing it and then expecting the consumers to determine the correct dosages.

4. ENVIRONMENTS

The main purpose of technical diving is to extend the environments into which diving is performed. This usually results in an increase in the hazards associated with such environments. The exception is a reduction of the N2 narcosis of deep diving, by the substitution of helium. Most of the other problems with deep diving are aggravated. Not only can the depth or duration of the dive be extended, but so can the actual diving terrain. This is the reason why many wreck divers and cave divers have embraced this activity.

5. ACCIDENT & RESCUE IMPLICATIONS

For the above reasons, the mixed-gas diver often wears a large amount of equipment, complex and bewildering (especially when problems develop during the dive). The likelihood of superimposed equipment problems is thus compounded. Difficulties include those of buoyancy and entrapment. Depth control requires greater discipline and skill as the margin between the "safe" depth and the oxygen toxicity depth, is much reduced. Sometimes a full facemask is indicated so that drowning becomes less likely and rescue more possible.

Because of the different equipment and gases, and the extension of the environments, the procedures for accident management and rescue may have to be altered to take into account the specific problems – such as difficulty in removal of heavy and cumbersome gear. With each variation from the conventional scuba system, there is a price to pay, and a possible modification of the first aid and treatment procedures.

OXYGEN PRESSURE

1. CNS AND RESP. TOXICITY
2. EFFECT ON RECOMPRESSION THERAPY
3. ? NITROGEN NARCOSIS & DCS
4. MIXING & HANDLING DANGER
5. HYPOXIC MIXTURES
6. CO2 BUILD UP
7. EQUIPMENT CHANGES

There is little concern about oxygen toxicity when diving with compressed air within recreational diving limits. Neurological and respiratory oxygen toxicity are virtually impossible. Also, the amount of oxygen exposure is unlikely to significantly influence any recompression treatments that may be needed for decompression accidents. Neither statement can be applied to technical diving.

It had been assumed that oxygen, by virtue of its replacement of nitrogen, would to some degree reduce the severity of nitrogen narcosis and decompression sickness. Although this is possibly so in theory, the scant experimental evidence that there is available, would suggest that oxygen may actually contribute to nitrogen narcosis. The possibility that O2 could contribute to DCS has been proposed, but this is unproven.

Inadequate mixing can result in oxygen pressures being higher or lower than intended. This has implications regarding the safety of the dive profile.

Higher oxygen levels are also likely to interfere with carbon dioxide transport in the blood. This has implications as regards carbon dioxide and oxygen toxicity, nitrogen narcosis and possibly decompression sickness.

The handling of gas mixtures, where oxygen is used or is added to air or other gases, can produce some hazards. Oxygen increases the risk of fire and explosion.

Some divers have observed that O2 aggravates the deterioration of soft materials, such as O-rings and other materials that comprise the diving equipment. It can also accelerate corrosion in cylinders.

See The Technical Dive, above.

OXYGEN ENRICHED AIR
or
NITROX (EANx)

CONFUSION of TERMINOLOGY and JARGON ——— SPECIFY or DIE

40/60 = 40% O2 (EUROPE) or 60% O2 (USA)

NOAA 36% + 32% O2	–	max. 1.6 ATA O2 pressure	
NURC, NC	–	max. 1.45 ATA	"
SWEDEN	–	max. 1.4 ATA	"
DAN (R. VANN)	–	max. 1.2 ATA	"

BUT O2 TOX = ?CNS, ?RESP, ?CO2. Specify which.

"EAD" = EQUIVALENT N_2 PRESSURE

Much of the technical diving now performed involves the use of nitrogen/oxygen mixtures in which the oxygen concentration is greater than that of compressed air. Under these conditions it is very important to specify exactly how much oxygen is being used. Such phrases as 40–60 or 60–40 are not only confusing but often misleading. In Europe 40–60 could imply 40% oxygen, whereas in the USA it is more likely to imply 40% nitrogen.

The actual percentages used in technical diving do vary with different countries and establishments but NOAA in the USA have chosen 32% oxygen and 36% oxygen as their two major mixes. These should not be referred to as Nitrox 1 or Nitrox 2, as this could also be misleading.

The EANx refers to enriched air (nitrox) with the x = oxygen percentage. Thus EAN 32 should mean 32% oxygen and not 32% nitrogen! Do not rely on jargon. Specify the exact mixture, in full.

Any EANx diving has a safe depth range less than air, due to oxygen toxicity.

The oxygen pressures that are considered acceptable vary with different authorities, and in many cases there is confusion between the neurological oxygen toxicity (which can result in nausea, vomiting, seizures, etc.) and respiratory oxygen toxicity, which tends to only occur with prolonged exposure. Also, many of the pressures being quoted in the literature refer to the oxygen pressures observed with rebreathinge quipment, when the carbon dioxide levels have not been measured – complicating considerably the actual cause of symptoms. Most of the work carried out during World War 2 and soon after, failed to measure the carbon dioxide levels and therefore their conclusions regarding safe oxygen limits, are questionable.

NOAA states that the maximum oxygen pressure acceptable is 1.6 ATA. The National Undersea Research Centre in North Carolina recommends 1.45 ATA. The Swedish authorities have recommended 1.4 ATA and Dr Richard Vann of the Divers Alert Network has suggested 1.2 ATA. The US Navy gives a much greater range, and relates it to the duration of the exposures.

The claimed advantages of EANx diving include a probable reduction in decompression sickness incidence, and a possibility of reduced nitrogen narcosis.

On a theoretical basis, presuming nitrogen pressure as the sole cause of nitrogen narcosis, a 20% oxygen mixture (air) at 23 metres could be replaced with 36% oxygen at a depth of 30 metres. to give an equivalent "narcotic effect". Experimental verification for belief in this theory has been sought, but it was unable to be verified.

A common claim is made that there is less post-dive fatigue with EANx than there is with air. This has not yet been verified.

LOW RISK NITROX DIVING

NITROX (EANx) REPLACES AIR. SAME EQUIPMENT
(Same Profile as AIR DIVE). RANGE 15 – 40 metres depth.

ADVANTAGES

1. LESS DCS
2. ? LESS NITROGEN NARCOSIS
3. ? LESS POST DIVE FATIGUE

DISADVANTAGES

1. GAS MIXING PROBLEMS
2. LESS MAX DEPTH (O2 TOXICITY)
3. ? DETERIORATION OF DIVE EQUIPMENT
4. ? MORE CO2 RETENTION

It is possible to use EANx to obtain possible advantages, with relatively few disadvantages, under certain conditions.

In this type of technical diving, the nitrox mixture, usually 32% or 36% oxygen, replaces air, but the same equipment is used and the same decompression profiles permitted, within the 15 – 40 metre range. Others use 28–40% oxygen, the latter with appropriate depth reduction.

It has been claimed that there is deterioration in the dive equipment by using high oxygen mixtures but this has not been verified. It is believed that halofluorocarbon O-rings (e.g. Viton) are less likely to oxidise and have a higher ignition point – and are thus frequently preferred by technical divers.

It is likely, because of the higher oxygen levels inhaled that there will be a concomitant degree of carbon dioxide retention, based on the common and competitive pathways for the transfer and transport of these gases.

HIGHER RISK NITROX DIVING

NITROX (EANx) REPLACES AIR — PROFILE AS FOR E.A.D.

ADVANTAGES RANGE 15 – 40 metres

1. INCREASED DURATION of NO-DECO DIVE
or LESS DECO STOPS
or GREATER DURATION/DEPTH of DIVE for SAME DECO
2. DECO VALUE — IF AIR STOPS FOLLOWED (LESS N_2)

DISADVANTAGES

1. GAS MIXING, HANDLING & CORRECT USAGE
2. MAX DEPTH LIMITED (O2 TOXICITY)
3. ?ALTERATION OF DCS & RECOMPRESSION THERAPY
4. ? DYSBARIC OSTEONECROSIS (SLOW TISSUES AFFECTED BY LONGER DIVES)

In this type of diving (EANx) the profile of the dive is altered to make allowance for the high oxygen, lower nitrogen levels, based on the EAD or similar calculations. Thus the diver is likely to increase the duration of his no-decompression dive, reduce the decompression stops required or increase the duration or depth of the dive for the same decompression time commitment. Whether this calculation is justifiable under all conditions, has yet to be demonstrated.

The probable only genuine safety advantage of this kind of diving occurs if "air stop" times are followed during decompression, whilst using EANx.

There is a possibility of an increased risk of decompression sickness, due to the effects of oxygen contributing to this disorder, or because of the use of untested algorithms used in commercial nitrox decompression profiles. The "bent" diver is also more likely to have had a higher oxygen dose, contributing to respiratory damage during the recompression therapy, than his air breathing colleague.

There may well be an alteration in the type of decompression sickness sustained with this form of diving because of the increased duration that it frequently entails. Thus the slower tissues are more likely to be affected, and this should be considered during the subsequent recompression therapies, and of a possible increased susceptibility to dysbaric osteonecrosis.

HIGH RISK, HELIUM DIVING

LESS DENSE, LESS SOLUBLE, FASTER DIFFUSION, HEAT CONDUCTIVITY

ADVANTAGES

1. LESS NARCOSIS — GREATER DEPTH
2. LESS BREATHING RESISTANCE — GREATER DEPTH
3. REDUCED CO2 RETENTION
4. LESS DECO (for LONGER DIVES)

DISADVANTAGES

1. DEEPER DIVING
2. MORE DECO (for SHORT DIVES)
3. HEAT LOSS (ENVIRONMENT, ? RESPIRATORY)
4. VOICE DISTORTION 5. MIXING 6. HPNS

There are significant differences in the way the body handles helium and nitrogen. Both are inert gases, but helium is much less dense and is also less soluble in some tissues than nitrogen. It does, however, have a much greater speed of diffusion and also conducts heat more rapidly.

The real advantage compared to nitrogen is that it does decrease the incidence of nitrogen narcosis. For dives in excess of 30 – 40 metres, the risks of nitrogen narcosis can be proportionately decreased as helium replaces nitrogen. It thus tends to be used for dives of greater depths. An additional factor is the reduction in breathing resistance due to its decreased density and other factors, also allowing dives to greater depths.

The effects on decompression likelihood are more complicated. It is probably likely to produce less decompression requirement for the longer dives, but may well require more decompression for shorter dives. Many of the helium and Trimix decompression tables are less well validated than the air tables, and herein lies a major difficulty with helium diving.

The main aggravating problem is that the divers are diving deeper with helium and Trimix than with compressed air, and therefore are exposed to all the associated problems of depth (other than nitrogen narcosis and breathing resistance). Barotrauma and DCS risks are aggravated. The environmental difficulties associated with depth include poor visibility, buoyancy implications, excess gas consumption, stress factors and the increased problems with first aid, rescue and resuscitation.

There is also a greater conductive heat loss from helium, even though there is some question regarding the respiratory heat loss. Heliox feels colder to breathe, and in a helium environment the heat is lost more rapidly. Increased depth also aggravates heat loss.

Voice distortion can produce communication problems. At greater depths the high pressure neurological syndrome (HPNS) also becomes relevant.

The difficulties with mixing gases, referred to above, are also present with helium and are complicated by the different compressibility of helium, as well as the risk of ascending with low oxygen pressures – which are commonly used with deep helium diving.

Comparison with the commercial deep divers is noteworthy. These experts usually require a surface supply of gas, full facemasks, communication systems, a standby diver, a wet bell and a recompression chamber on site. Experience has demonstrated the need for these. The less trained amateurs appear to have no such requirements.

VERY HIGH RISK. RE-BREATHERS or CIRCUIT SETS

Rebreathing equipment has been in use for more than a century, causing many deaths and cases of unconsciousness. Despite the recent electronic mechanisms, the essential problems of rebreathing equipment remain. It is very much a high risk strategy to employ for specific reasons, by professionals.

The value of rebreathing equipment is that it produces fewer bubbles, and is therefore quieter. This is of use both in clandestine military operations and for marine photography. It is more economical on gas, as the gas is recycled through the diving equipment, in a "circuit". It can also be constructed with low magnetic materials, which are useful if one is working around magnetic mines.

The disadvantage that is inherent in all types of rebreathers is the failure of the carbon dioxide absorbent system to work effectively under all diving conditions. This may occur for various reasons. One is an inappropriate canister design. The early absorbent canisters were inadequate for maximal exertion. It is surprising how few improvements the manufacturers have included in some of the carbon dioxide absorbent canisters in the sets now being promoted. Also, the absorbent itself is not always reliable. It frequently varies in efficiency, and each absorbent batch needs to be tested. This is not feasible for the individual diver. The handling and storing of absorbent may result in deterioration in efficiency, as will the degree and type of wetting that may occur.

When diving in sea water, hypertonic saline can enter the system, causing a great reduction in efficiency. The absorbent itself, when combined with carbon dioxide, produces water as a by-product, which can also influence the efficiency. Water traps are incorporated in some sets.

REBREATHERS

ADVANTAGES

SILENT, ECONOMICAL, +/- MAGNETIC

DISADVANTAGES

1. CO2 TOXICITY
2. DILUTION HYPOXIA, HYPEROXIA
3. CAUSTIC COCKTAIL
4. INITIAL and MAINTENANCE EXPENSE

OXYGEN RE-BREATHERS :
DEPTH LIMIT 8 – 9metres

CONSTANT FLOW. O2 = FLOW vs. ENERGY

OXYGEN MONITORS = FAILURE. DCS?

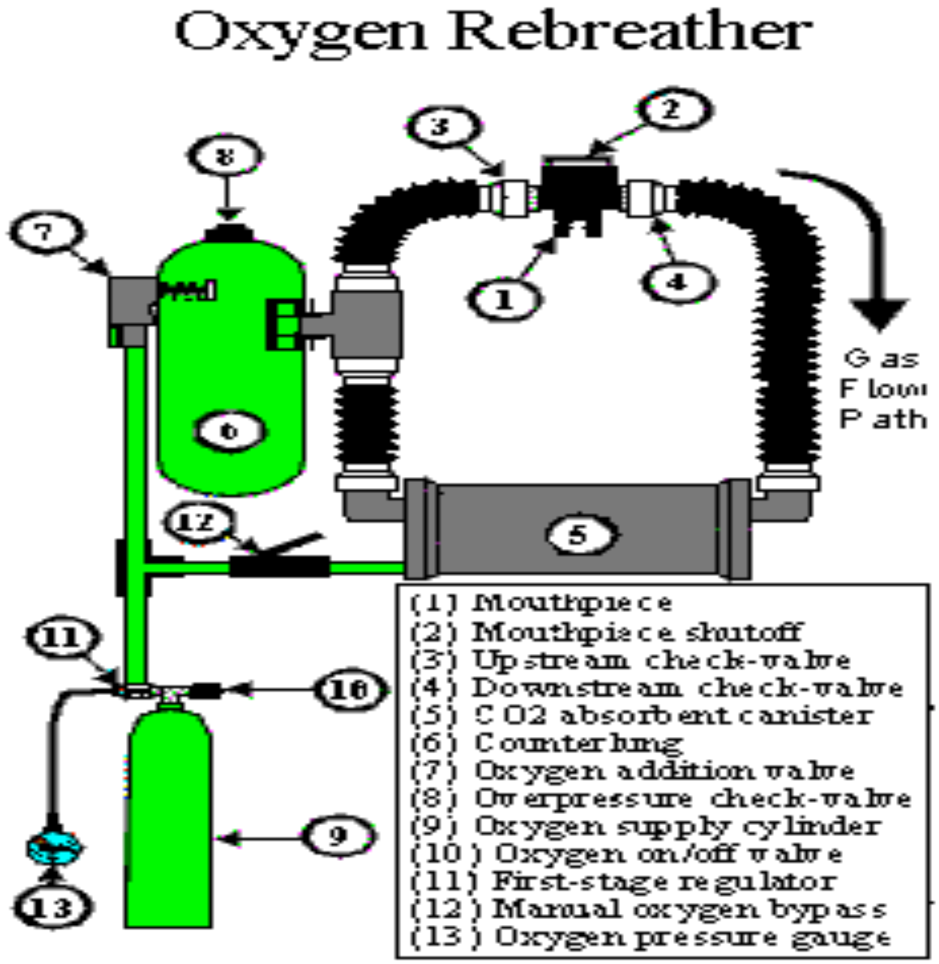


Fig. 43.1

The carbon dioxide absorbent must be packed correctly into the canister. This is an acquired skill and requires training. The density of packing influences the efficiency. Lower temperatures also reduce the efficiency of the absorbent. Some absorbents can be pre-pachaged.

Often absorbent canisters will work very well at a moderate work load, but when exertion is required, the absorbent canister will eventually fail – especially if it has been in use for a considerable time.

The manufacturers' claims regarding the safe duration of carbon dioxide absorption in their diving equipment are usually very optimistic, and do not apply to emergency situations where the diver is exerting himself maximally (such as when swimming against a current, or trying to rescue and tow a companion – even on the surface).

When water gets into the rebreathing set, it may collect some of the alkali from the absorbent and enter the divers mouth and lungs, which can be very unpleasant. This is called a "caustic cocktail".

A rebreathing set can cause dilution hypoxia, usually by incorrect technique and failure to "clear the set" (and the lungs) of the inert gas. This is more likely when the supply gas is on demand, compared to the old fashioned constant flow sets. It can also occur if there is a small amount of inert gas in the gas cylinder, and especially so when there is a considerable amount of nitrogen or helium, such as with nitrox, heliox or trimix diving. It may be induced by an incorrect mix, a leak from or obstruction to the inflow, or low cylinder pressure. It can even occur in 100% O2 sets, especially those that supply gas on demand.

Sometimes the hypoxia will only be noticed during ascent. A lower oxygen percentage at depth may translate to a dangerously low oxygen partial pressure nearer the surface.

Re-breathers require specialised diving protocols, when rescue and resuscitation are needed. It is not just a matter of removing a mouthpiece and replacing it with another. Companion diver drill needs to be tailored for each type of re-breather.

The problems of gas mixing and handling, as described above, also relate to this equipment.

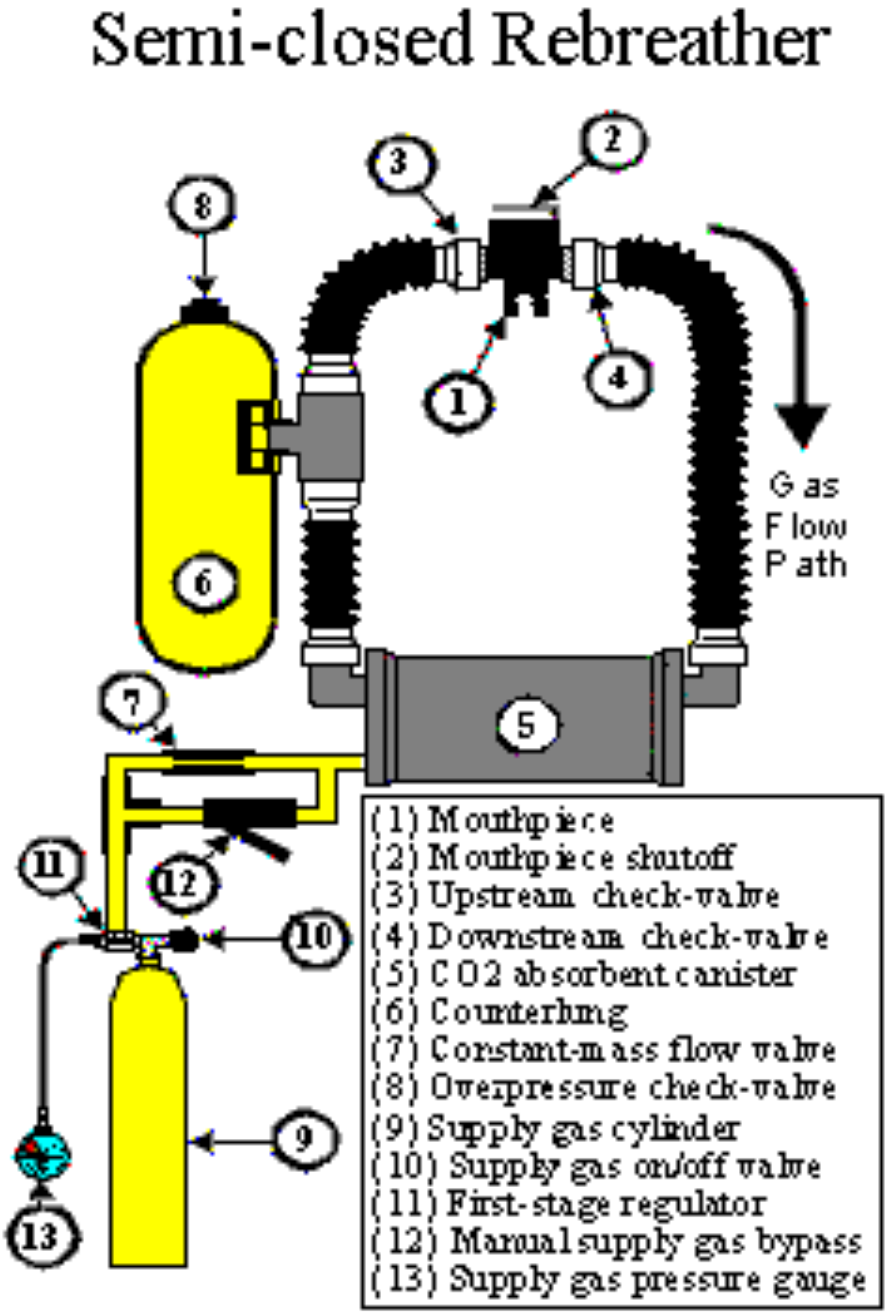

Semi-closed Rebreather
1
2
3
4
5
6
7
8
9
10
11
12
13
Gas Flow Path
(1) Mouthpiece
(2) Mouthpiece shutoff
(3) Upstream check-valve
(4) Downstream check-valve
(5) CO2 absorbent canister
(6) Counterlung
(7) Constant-mass flow valve
(8) Overpressure check-valve
(9) Supply gas cylinder
(10) Supply gas on/off valve
(11) First-stage regulator
(12) Manual supply gas bypass
(13) Supply gas pressure gauge

Fig 43.2

• The oxygen rebreathers are closed circuit sets, used to a maximum depth of about 8-9m, are usually restricted to specialised navy divers. They have resulted in many cases of unconsciousness and death.

Occasionally photographers use this equipment, but they would be considered unwise to do so. The companion rescue drill is often required and marine photographers are not gregarious beasts.

• Some rebreather sets have a constant flow of nitrox, heliox or trimix gas. They are usually semi-closed circuit sets. With these, the oxygen level in the breathing bag or inspiratory tube may vary according to two major factors. The first is the flow of oxygen into the set, and the second is the amount lost from the set. The inspiratory oxygen range can be a variable quantity, and should be designated pre-dive. The relevant factors determining inspiratory oxygen include:

– the volume and mixture of the incoming gas
– the energy utilised in metabolism (oxygen consumption)
– the volume and mixture of gas released as bubbles (e.g. with ascents).

The interaction between the input and output of oxygen will result in a variable oxygen percentage and ascent or descent will then determine the oxygen pressure. These sets are especially likely to cause dilution hypoxia and hypoxia of ascent.

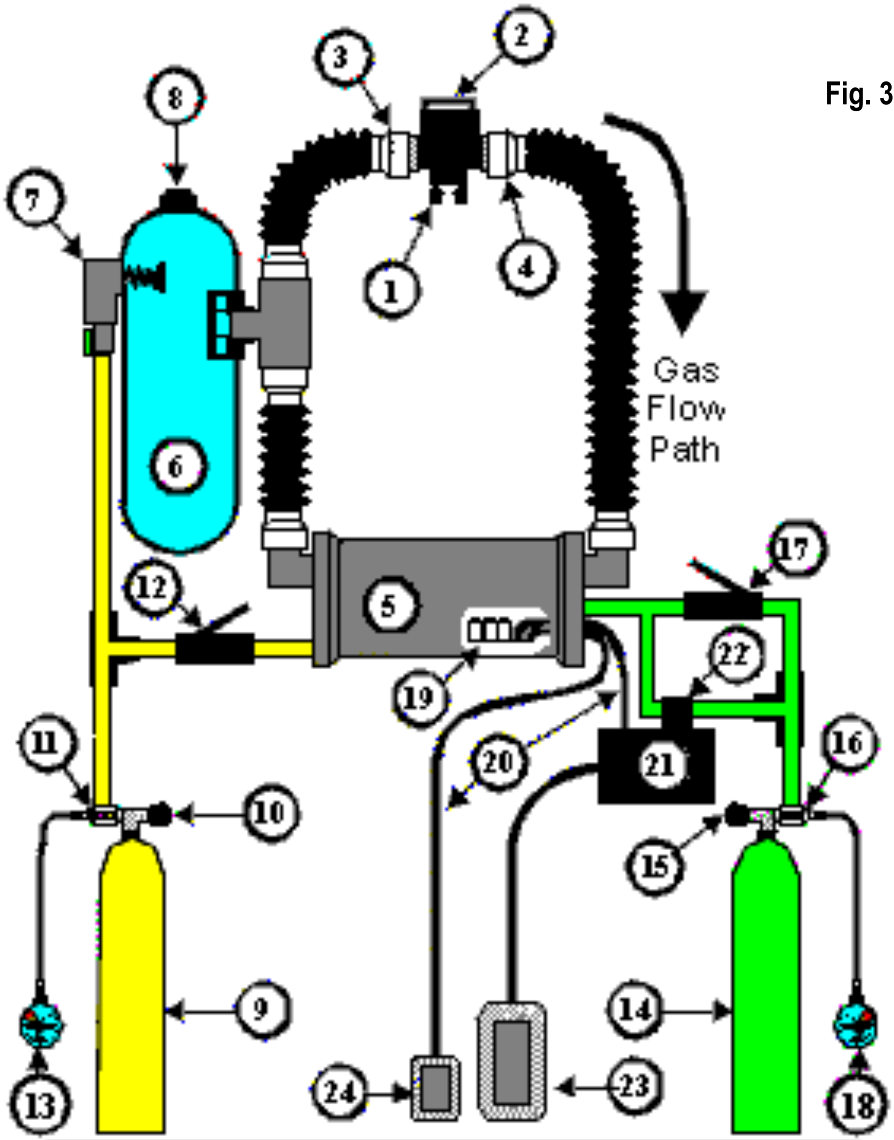
As hypoxia usually produces no warning prior to it causing unconsciousness, the use of constant flow rebreathing sets would be considered unwise. Close attention to the cylinder pressure, ensuring an adequate inflow of gas, and a replacement with fresh gas prior to ascent (a "flush-thru") is essential

• The more expensive closed circuit mixed gas rebreathing sets use analysers and solenoids to measure and control the oxygen pressures during the dive and a feed back system adds oxygen or a diluent gas (nitrogen, helium, mixtures) as required – to ensure that the oxygen partial pressure remains within a certain range. This equipment is extremely expensive, often not reliable and should only be used by those with faith in this technology.

N.B. Anyone who uses a rebreather should be aware of the much greater risk of unconsciousness. Without a full facemask, this problem usually converts to subsequent drowning and death.

Closed-Circuit Rebreather

Fig. 34.3



(1) Mouthpiece
(2) Mouthpiece shutoff
(3) Upstream check-valve
(4) Downstream check-valve
(5) CO2 absorbent canister
(6) Counterlung
(7) Diluent addition valve
(8) Overpressure check-valve
(9) Diluent supply cylinder
(10) Diluent on/off valve
(11) Diluent regulator
(12) Manual diluent bypass
(13) Diluent pressure gauge
(14) Oxygen supply cylinder
(15) Oxygen on/off valve
(16) Oxygen regulator
(17) Manual oxygen bypass
(18) Oxygen pressure gauge
(19) Oxygen sensors
(20) Oxygen sensor cables
(21) Main electronics
(22) Oxygen solenoid valve
(23) Primary display
(24) Secondary display

CONCLUSION

There are few problems in understanding the general concepts of technical diving, using different gas mixtures, different equipment and extending limits beyond those of recreational diving. The principles are relatively simple. The devil is in the application.

Perhaps the most important thing about technical diving is to realise that the majority of the diving deaths that occur in recreational divers occur for reasons which will be aggravated by the use of more complex equipment, in more hazardous environments. Technical diving is therefore, by its very nature, likely to have greater risks than normal recreational diving, other factors being constant.

The margin for error in this type of diving is appreciably less, and therefore it should only be employed by divers with enormous experience, detailed training and meticulous attention to equipment selection, maintenance and use. The advocates of technical diving tend to lay great stress on certain aspects of safety - which are relatively unimportant compared to the others referred to in Chapter 34.

To overcome some potential equipment related problems, technical divers may stress the need for redundancy, redundancy, redundancy. Complexity is an unintended accompaniment.

They will stress the importance of decompression sickness, and the physiological advantages of oxygen, but may ignore the more frequent causes of diving deaths, such as exhaustion of gas supply, buoyancy problems, stress responses, etc. They will also tend to ignore the areas in which the "technical advances" have been meagre e.g. the efficiency of carbon dioxide absorbents, to focus in preference on high-tech oxygen sensors and theoretical decompression algorithms.

The leaders in this field will be experienced, highly skilled, very fit, entrepreneurial divers often with a high public profile. It is not for occasional, pleasure seeking divers who anticipate a relaxed, hassle free, unencumbered dive and an automatic expectation of survival at the end of the day.