


The Technical diver

By Alain Norro PhD


1

1

2

2

The Technical (TEK) diver

- Today's landscape of the diving industry
- Definition of technical diving
- Risk associated with technical diving
- New domain of exploration - specificities, stress & task load
- Equipment for the technical diver
- Helium, the inert gas used to lower the Nitrogen narcosis
- Decompression of the technical diver
- Gas density
- Risk revisited

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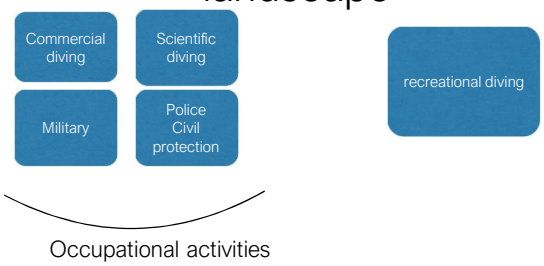
3

The 'diving industry' landscape



Regulated by law in many countries like BE

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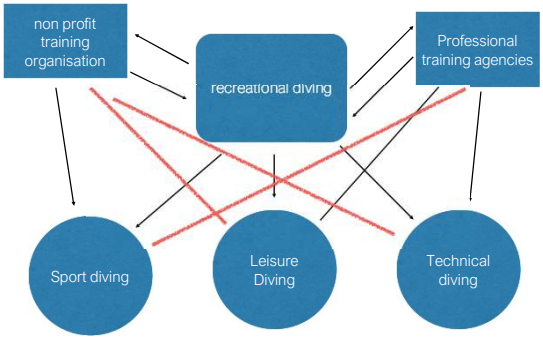
4

Technical diving



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5

Technical diving

recreational diving

- Technical (TEK) diving is a form of recreational diving
- Diving equipment evolution & new techniques (Nitrox - Trimix - Rebreather) permit to extend the usual domain of scuba diving (40m -15 min deco)
- Deep, cold, dark, overhead environments (caves, wrecks, long deco) are new domains explored by the TEK diver

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6

Risk associated with TEK diving

- Exploration of new area increases the level of risk
- In the late 90' TEK diving was described as a 'deadly' activity. *
- Today with an appropriate training & reliable equipment the situation improved and with the correct 'attitude' the risk remains 'controllable' **
- More info at the end of the presentation

* Edmons C 1997. Spums journal vol 27,3. ** Fock A. 2013 DHM. Vol 41 n°2

7

New domain of exploration

- The TEK diver explores domain ranging from 40 to 120m depth and beyond …
- Bounce dive duration extends to few hours in the mesophotic zone
- Thermal protection is essential drysuit is basic equipment of the TEK diver and in some case hot water can be used during the long ascent to the surface

8

New domain of exploration

- Overhead environment is 'classical situation' in TEK diving
- It could be Cave, Wreck, Ice or decompression obligation
- No direct access to the surface is possible…

9

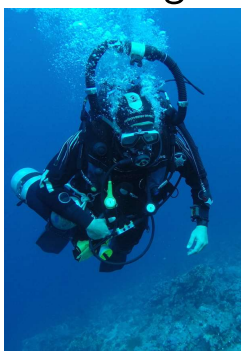
New Stress

- Pressure
- Cold
- Biophysical effect of gases
  - Oxygen (hypoxia (Po_2< 0,16 b) - hyperoxia (Po_2>1,6 b)
  - Nitrogen (narcosis) PN_2 > 3,2 b

10

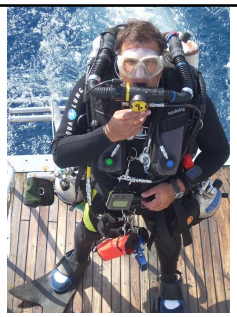
Task load in TEK diving

- More complicated equipment configuration or procedures bring more tasks to be undertaken by the diver
  - Management of numerous tanks and gases
  - Management of equipment failure underwater B.O etc,…
  - Management of long decompression underwater - gas change, current, waves,….



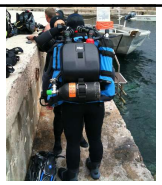
11

Equipment



- Probably the most relevant exemple of new equipment commercially available for the TEK diver is after the drysuit, the closed circuit rebreather (ccr)
- Moreover, redundancy is the principle for vital equipment

12

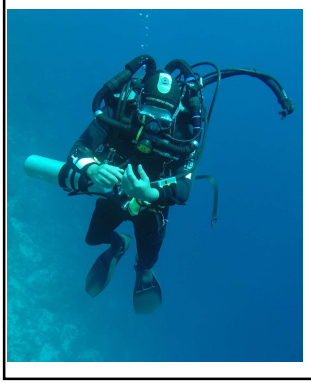


CCR

- Long history of rebreather (semi-closed, closed)
- CCR commercially available from 1997 as a piece of diving equipment by buddy in UK (Inspiration)
- The 'dramatic' gas efficiency of the CCR made possible access to new territories in technical diving

13

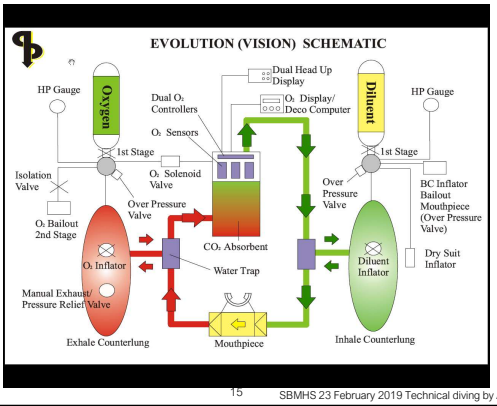
What is a CCR ?



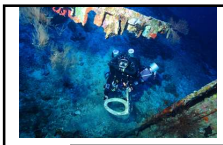
- A closed breathing loop waterproof & one way
- A system of filtration of the CO_2
- A system of addition and control of the oxygen

14

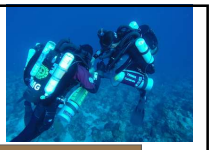
What is a CCR



15



CCR



Pros	Cons
Gas effficiency	Cost
Optimised deco - Po_2 cste	Sophistication
Warm & moist gas	More care needed
Furtif	increased risk ?

In 2019, rebreather is THE diving apparatus for deep trimix dives

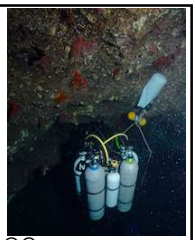
16

Helium

- Helium is used by the TEK diver to reduce nitrogen narcosis
- Less nitrogen but oxygen cannot be increased
- Third gas needed to replace some nitrogen
- Trimix-blend of 3 gases Oxygen/Helium/Nitrogen
- Trimix 15/30 often used as diluent gas on CCR to 55 m

17

Helium-TRIMIX



- Normoxic trimix with 20 % oxygen 20/25 in OC
- Hypoxic trimix with less than 16% oxygen 8/72 dil to 120m
- Heliair (10/50), Heliox (5/95), Triox (50/10),…

18

Helium

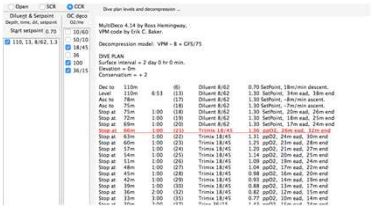
- 'Rapid gas' higher diffusion (2,65 * Nitrogen)
  - *Ascent from depth MUST be always controlled !*
- Less soluble than Nitrogen (1,5 less than N)
  - *Second inert gas introduced (more deco)*
- High thermal conductivity (5 * air)
  - *Enhanced thermal protection of the diver compulsory*

19

Decompression

Hamilton et Thalmann (2004)

"The key to making technical trimix diving practical was the ability to perform an efficient and reliable decompression from a dive with minimal narcosis and without posing a substantial risk of oxygen toxicity"



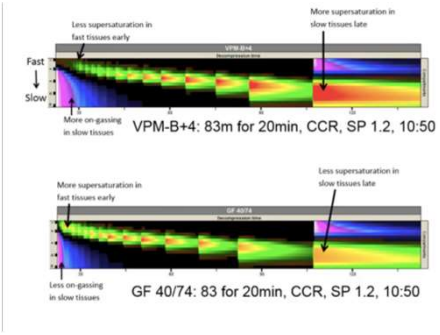
20

Decompression
Deep stops

- Still controversial today even if some benefits but how much ?
- Bubble Models against Dissolved Gas Models
- Bubble model keeps the diver deep at the start of deco to reduce the initial supersaturation (to prevent the bubble formation) but therefore undershoot the deco close to the surface (end of the deco)
- Nowadays bubble models are less and less used by the tek diver

21

From Mitchell, 2015



Keeping the diver deep at the start of the deco seems not protective
USNavy Deep stop study 2011 (diving on air)

22

Decompression

- Today the TEK diver uses modified Bülhmann model called Bülhmann 'GF' model for Gradient Factors
- This modification permits to generate deep stop
- GF Low for the deep part of the deco and GF High for the shallow part of the deco
- The next question is what value to give to those GF …

23

GF ?

- GF high is generally setup to 90-95 for diving on air and lower to 80 or even 70 for trimix diving depending on P* SQRT t
- GF Low is setup to 90-95 for diving on air and to 40 or lower for diving trimix depending on P*SQRT t
- No exact rule ! the idea being not to start the deco too deep
- Exact deco unknown

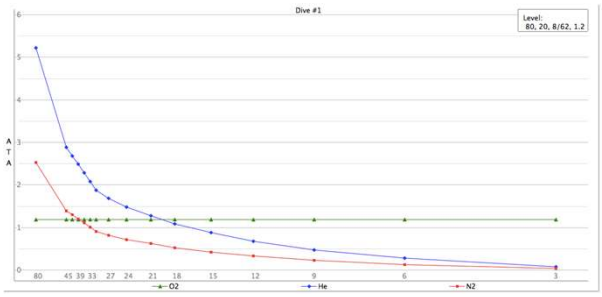
24

Surface Deco

- Some pro divers use TEK diving and also the surface decompression
- All deco underwater to the 9 m stop
- Start few minutes at 6m on 100 % oxygen then go to surface and complete deco in the chamber starting again at 6m

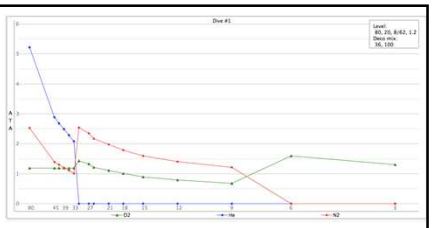
25

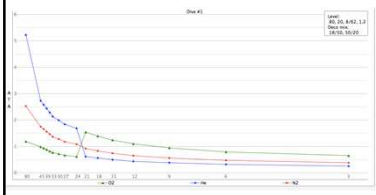
Normal ccr dive 80m 20 min with dil gas 8/62, SP 1.2 b
RT 106 min GF 40/80 ZHL16-C



26

Gas change
during
Decompression
Or
Bail out CCR





27

Gas density

Less than 6.2 g L^{-1}

Gas	Density ($g \cdot L^{-1}$)
Hydrogen	0.090
Helium	0.179
Nitrogen	1.251
Oxygen	1.428
Air	1.293

Table 1. Gas density in $g \cdot L^{-1}$ for common diluent gases, oxygen and air at 1.0 ATA. Data from Doolette and Mitchell (2011).

28

Risks assessment CCR diving

- No CCR are more dangerous to use than any other CCR
- Attitude is saving life in CCR diving
- Same risk is mCCR than in eCCR
- Lower risk if bail-out gas is present during the dive
- Always dive a CCR fully functional !
- Risk is far more related to the 'Human' than to the 'Machine'

78 Diving and Hyperbaric Medicine Volume 43 No. 2 June 2013

Analysis of recreational closed-circuit rebreather deaths 1998–2010

Andrew W Fock

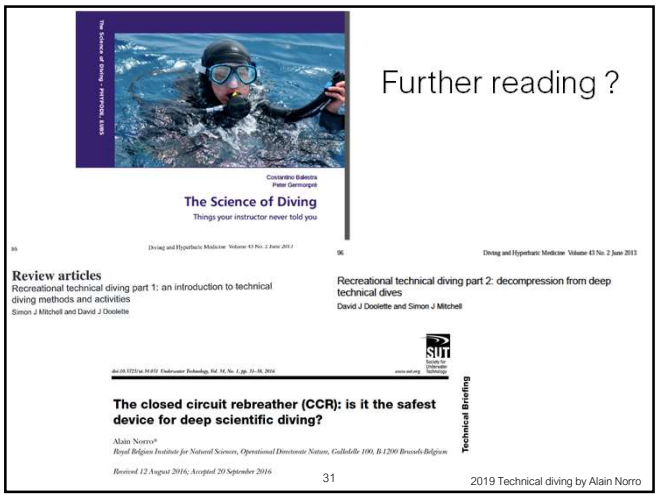
29

Risk assessment CCR diving

- 14000 CCR divers in 2010
- 4 fatalities on 100000 dives
- 10 * more than in Leisure diving
- Reduced to 4* more if BO gas is taken ….
- 2/3 of the dives are at risk
- Attitude keep the diver alive !

1 low risk, < 40 msw, all checks and tests conducted, no wreck/cave penetration;
2 moderate risk, < 40 msw, all checks done, wreck or cave penetration performed;
3 intermediate risk, > 40 msw, all checks completed;
4 high risk, > 40 msw, all checks and tests done, wreck or cave penetration;
5 extreme risk, > 150 msw or checks not done or alarms ignored.

30


Further reading ?
The Science of Diving
Things your instructor never told you
Costantino Balestra
Peter Germonpré
Review articles
Recreational technical diving part 1: an introduction to technical diving methods and activities
Simon J Mitchell and David J Doolette
Recreational technical diving part 2: decompression from deep technical dives
David J Doolette and Simon J Mitchell
The closed circuit rebreather (CCR): is it the safest device for deep scientific diving?
Alain Norro*
Technical Briefing
31
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31