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AR-Sub α



Long range hyperbaric rebreather



AQUA LUNG
Military & Professional

A semi-closed circuit rebreather dedicated to submarine rescue systems.

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SUBMARINE ACCIDENT

Immediate risks :

- Blast
- Temperature
- Panic

Persistent risks :

- Airborne pollutants – irradiation
- Loss of life support capabilities
- Uncontrolled flooding
- Internal pressure rises \Rightarrow partial pressures ++

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Senior survivor decisions depends of:

- Depth
- Onboard situation
- Surface conditions and available means

Choices are :

Self escape ?

Waiting for assistance ?

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Waiting into a pressurised air atmosphere

During 3 to 5 days by increased pressure, mainly
the result of flooding

Bodies of survivors are saturated by Nitrogen

⇒ slow deco needed

Bodies of survivors are exposed to O₂ toxicity

⇒ several types



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Oxygen toxicity

Two main forms of toxicity:

- Central Nervous System
=> $ppO_2 > 1,7 \text{ Bar}$
- **Pulmonary**
=> $ppO_2 > 0,5 \text{ Bar}$: Lorrain Smith effect

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Submarine rescue transfer under pressure system

The Nato Submarine Rescue System example

NSRS



© Mer et Marine

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Submarine rescue system

- Fully air transportable
- Launch and recovery up to sea state 6
- Reach of a distress submarine (DISSUB) in 72-96 hours from the alert
- Up to 610-meter-depth
- Up to 6 ATA inside the pressure hull
- Atmosphere : **AIR**
- Each run : 15 rescuees – Total capacity : 72



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Rescuers mission

Operating into a pressurised air atmosphere

During several hours / days, the rescue team (used as attendants) will support submariners. They will be exposed to the same O₂ toxicity from the pressure balancing phase (opening of the DISSUB hatch) until the end of decompression (same deco than rescues).

Main assumption :

Presence of survivors after several days confirms the breathability of the internal atmosphere (nevertheless, it may be safer to filter and to clean this air before to be inhaled).



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Pulmonary Oxygen Toxicity

Lorrain Smith effect

- Decrease of vital capacities challenging the decompression plan
- Cumulative toxic dose => Oxygen Toxicity Unit (OTU)
- REPEX algorithm : high dose OTU => irreversible lung damages
- Count down starts as soon as the ppO₂ is more than 500 mBar (beyond 15 MSW breathing normal AIR)

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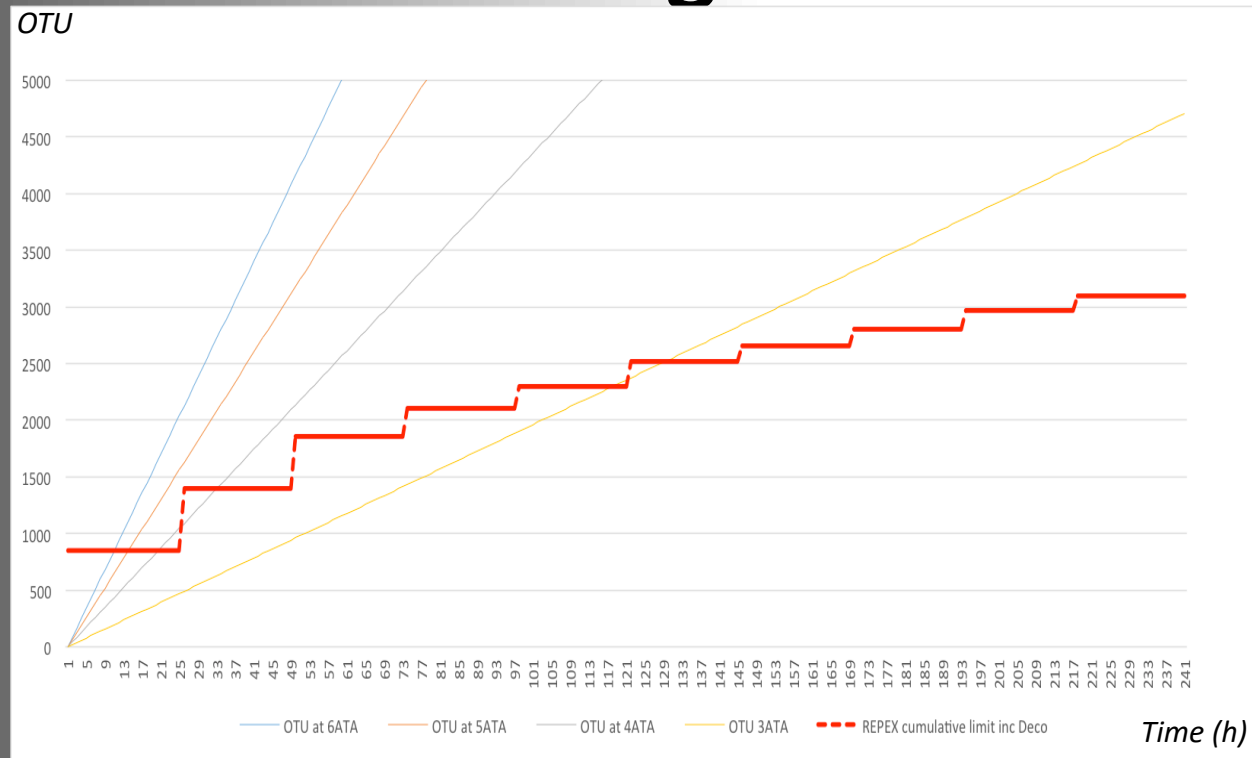


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Pulmonary Oxygen Toxicity REPEX algorithm



OTU level caused by breathing Air at higher pressures. The safe zone is below the cumulative dose line, the REPEX limit. 1425 OTU carries a 10% risk of lungs damage.

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DISSUB partial pressure of AIR atmosphere

Depth (MSW)	P (ATA)	ppO2 (Bar)	ppN2 (Bar)
0	1	0,21	0,79
10	2	0,42	1,58
20	3	0,62	2,38
30	4	0,83	3,17
40	5	1,04	3,96
50	6	1,25	4,75
60	7	1,46	5,54

The first assumption is “no survivor beyond 6 ATA”



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Military context

Dilemma => to reduce OTU with an acceptable DCI risk

DCI risk expected to be less than **2%**

> 700 OTU : early pulmonary symptoms

>**1700 OTU** moderate pulmonary symptoms



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Conservative deco table considering attendant's safety

NSRS CPR 11 (AIR + 100% O₂ periods)

Depth (MSW)	10	20	30	40	50
Deco duration (h)	25	40	50	56,6	60
Predicted DCI (%)					
12h at max depth + deco	0	0	0	0,006	0,022
OTU during decompression	413	706	1013	1370	1500
Max stay (h) at max depth for OTU <1700	∞	50	16	5	2
Max number of SRV runs (approx)	∞	>12	4	1	0
Max number of rescuees	ALL	ALL	60	15	0

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Modification of the rescue system / procedure

Reduce OTU during the stay at max depth (and eventually during beginning of the deco)

- For attendants (healthy military crew)
- For submariners (IOT increase success of the deco)



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A rebreather dedicated to this mission

The intrinsic function of AR-SUB ALFA is to automatically **regulate the partial pressure of oxygen** (ppO₂) in order to keep the user's OTU under the **Pulmonary Oxygen Toxicity REPEX** limit.

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Specifications

Dimensions	380 x 400 x 220 in mm
Weight	10 Kg
Power supply	Stand AA Battery (→ IMCA compliant)
Autonomy	Power 12h / CO2 Scrubbing 6h
Carriage	Back / Front position
Monitoring / control	O2/CO2/OTU
CO2 Scrubbing	cartridge or Soda sorb
Air filter cartridge	RD 90 Standard fitting

The selection of the air filter cartridge can be configured to the pollutant encountered

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French Navy trials in progress since April 2019

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Thank you

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