

Rebreathers: Stealth Diving

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Disclaimer

- I am not a rebreather instructor, just a user.
- This talk only scratches the surface of the complexities of rebreathers.
- Diving a rebreather takes some **SERIOUS** instruction.

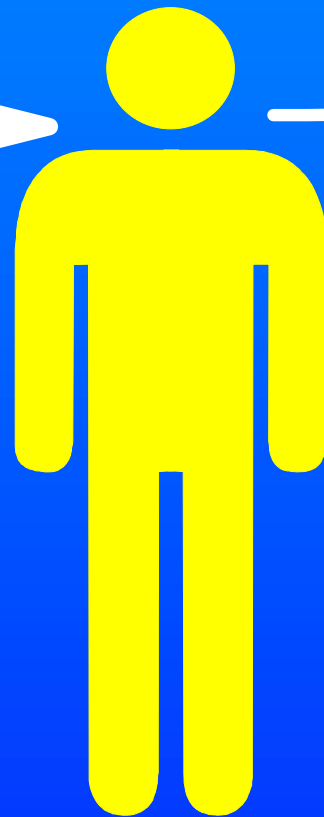
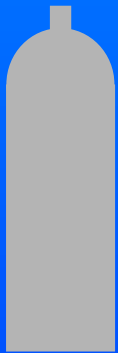
Types of SCUBA

- Open Circuit - Air
- Open Circuit - Nitrox
- O₂ Closed Circuit Rebreather
- Mixed Gas Closed Circuit Rebreather
- Semiclosed Circuit Rebreather

Open Circuit SCUBA

Bubbles

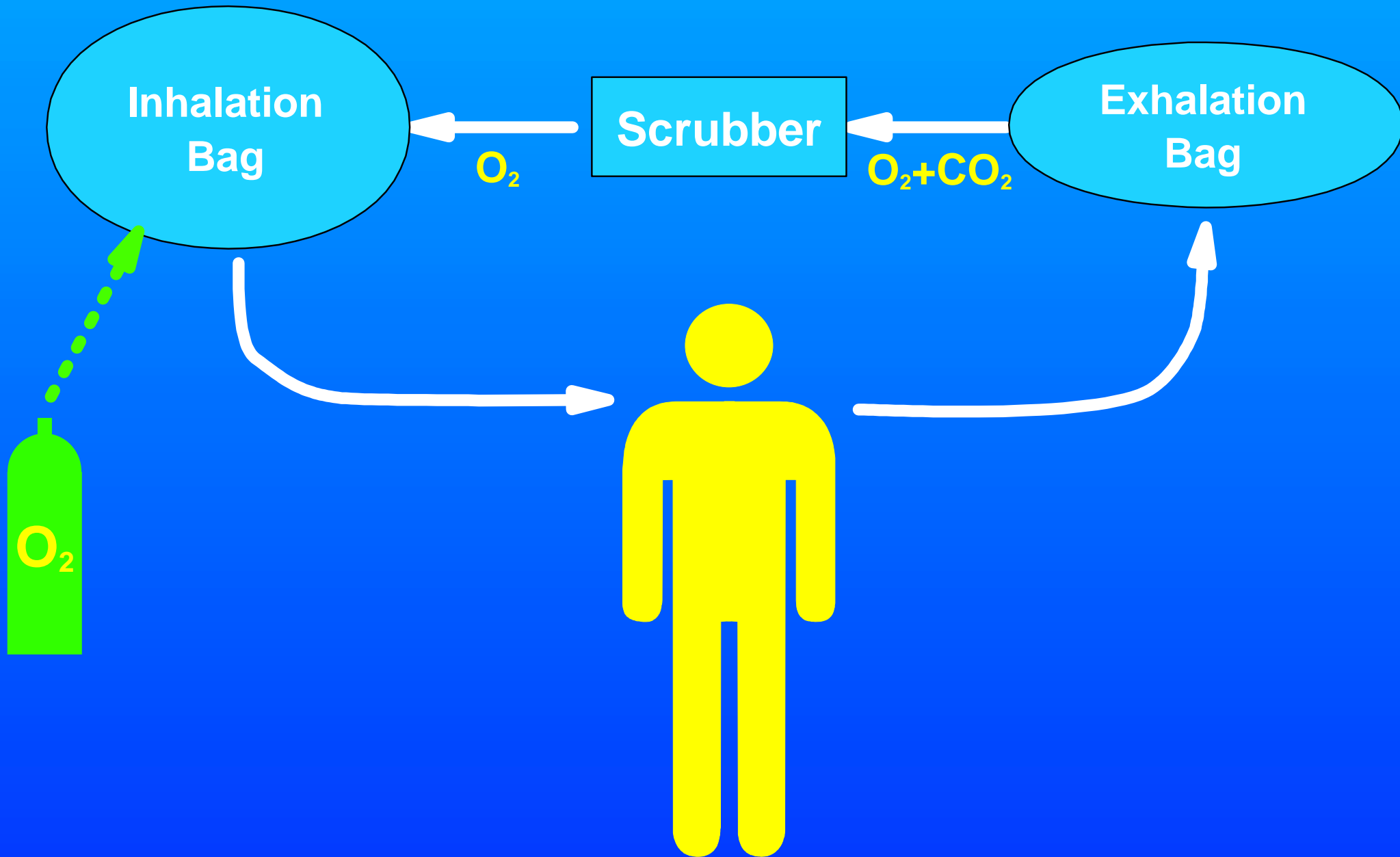
Air or Nitrox



Open Circuit - Air & Nitrox

- Lots of bubbles, water disturbance
- Max depth function of mix (typ: 80-180')
- Run time: 30-60 minutes
- High gas consumption
 - Increases with depth
 - Increases with exertion
 - Increases with newbiness
- Unit Cost: \$0.6-2K

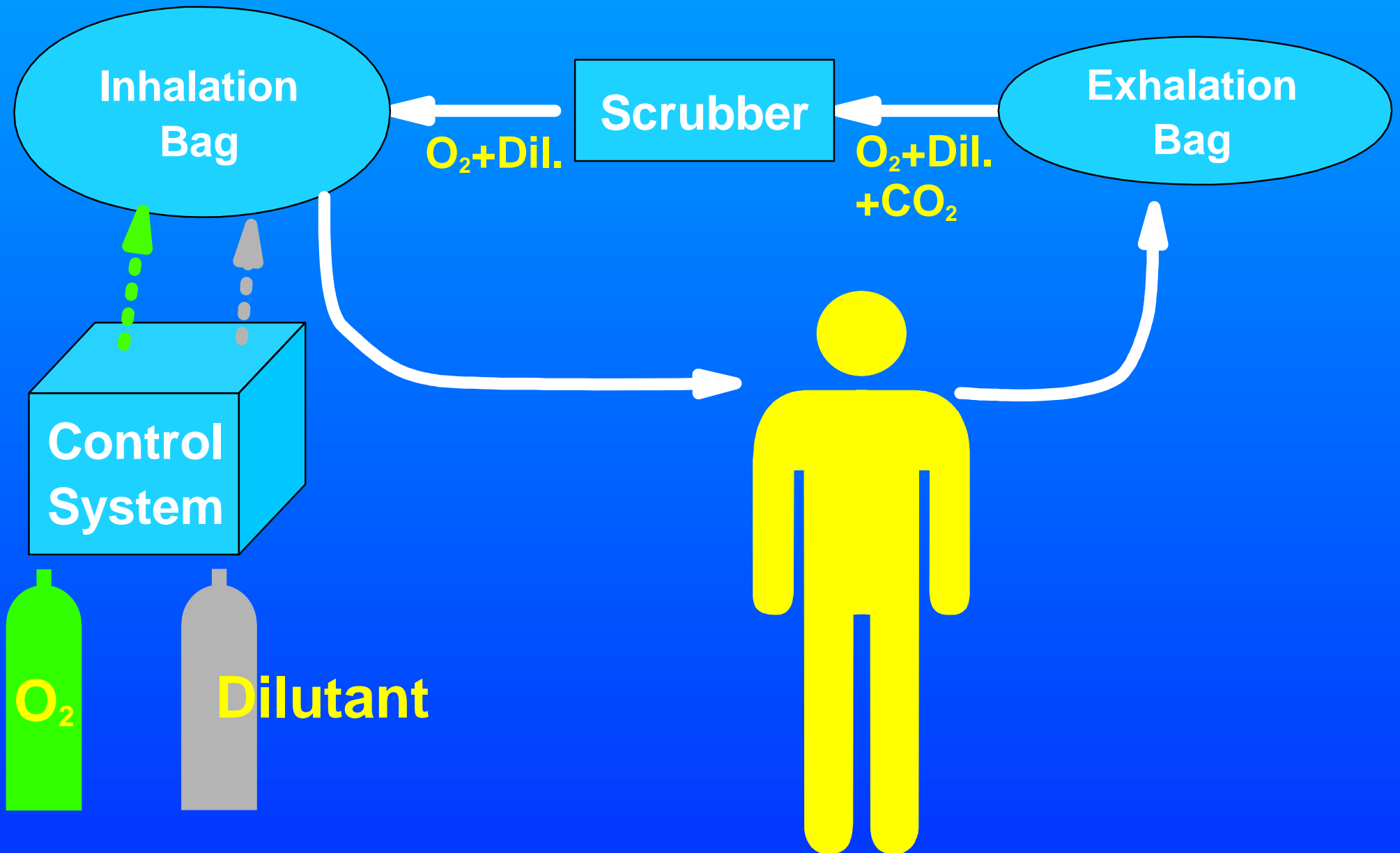
O₂ CCR Loop



O₂ Closed Circuit Rebreather

- NO bubbles (unless you go up fast)
- Max depth 25-33' (CNS OxTox on pure O₂)
- Gas consumption independent of depth
- Run time: 1 to many hours
- Unit Cost: \$2K and UP
- Interesting for Navy SEALs and DFG
- Draeger LAR-V

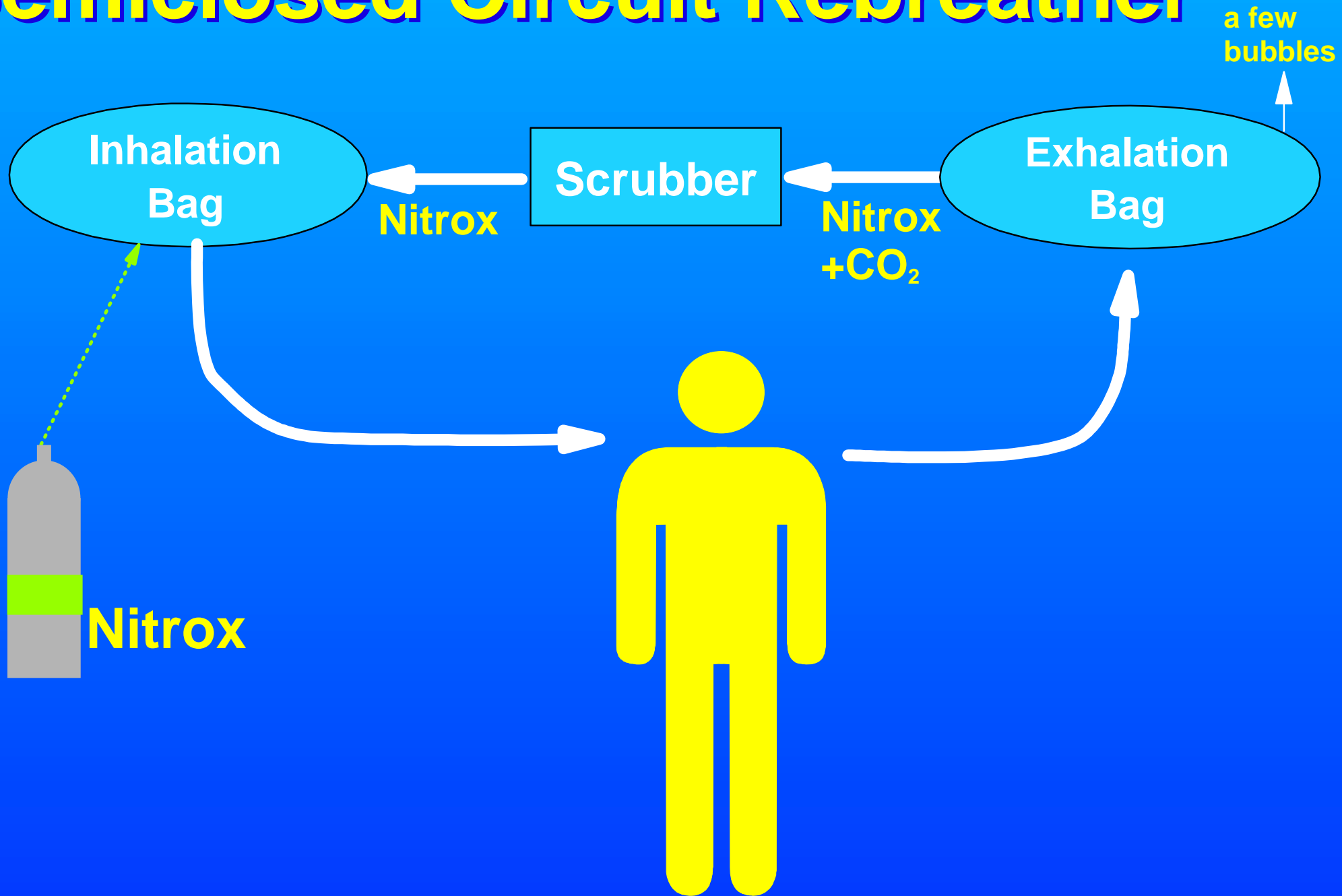
Mixed Gas CCR Loop



Mixed Gas Closed Circuit RB

- Used by Astronauts!
- NO bubbles unless you go up
- Max depth 1800'+ (!!)
- Gas consumption independent of depth
- Run time: many hours
- VERY high mechanical & electronic complexity
- Unit Cost: \$8-65K (!!)
- Cis-Lunar, Mk 15/15.5/16, Inspiration

Semiclosed Circuit Rebreather



Semiclosed Circuit RB

- Few bubbles, none for a minute or two
- Bubbles are behind you
- Max depth function of mix (typ: 80-180')
- Gas consumption independent of depth
- Run time: 35 minutes to many hours
- High mechanical complexity
- Unit Cost: \$3K-7K
- Dolphin/Atlantis, Halcyon, Mares

Draeger Dolphin Maintenance

- Extra 60 minutes before dive day
 - Fill sorb canister
 - Assemble ("red to red or you'll be dead")
 - Flow test
 - Positive pressure test
 - Negative pressure test
- Extra 30 minutes post dive day
 - Disassemble
 - Empty sorb canister
 - Rinse, disinfect, and dry
- If you can't program a VCR, ...

New Risks

- Hypoxia - too little O₂
 - Equipment failure
 - Out of gas, but you can still breathe
- Hypercapnia - too much CO₂
 - Slightly flooded loop
 - Exhausted sorb
- Caustic cocktail
 - Very flooded loop
- Biologicals
- Bankruptcy

Economics

- Startup Costs (Draeger Dolphin)
 - Equipment: \$3500
 - Training: \$500 (plus Nitrox class)
- Per Dive:
 - Custom blend Nitrox fill: \$7-10
 - Pony bottle fill: \$3 (per two dives)
 - Sorb: \$12 (per four dives, doesn't keep till next weekend)

Some Rebreathers

- LAR-V (O₂ CCR) \$???
- Draeger Dolphin (SCR) \$3,500
- Halcyon (SCR) \$7,000
- AP Valves Buddy Inspiration (MGCCR) \$7,000
- Navy MK15 (MGCCR) \$65,000 (new), \$10,000 (surplus and rebuilt)
- Cis-Lunar (MGCCR) \$20,000

Why Bother?

- Low/no bubbles
 - Photography: Fish, invertebrates (!!), marine mammals
 - Research
 - Military
- Very long run times
 - Cave penetration
 - Deep dives with long deco
- Adjustable PPO₂ for very deep dives (MGCCR)
 - Marine Biology
 - Filmmaking
 - Oil rig maintenance
 - Phone taps

Minor Advantages

- Warm air
- Moist air
- Small tanks
- FO_2 drops with exertion - less OxTox risk

Draeger Dolphin Disadvantages

- Heavy
- High swim resistance
- BC is a pseudo-tek Zeagle
- Pony could be designed out
- Tank mix determines MOD, bag mix determines nitrogen loading.

How Deep? How Long?

- 36 mix, 40 orifice: 114' MOD, 45-69 minutes
- 40 mix, 40 orifice: 99' MOD, 45-69 minutes
- 45 mix, 50 orifice: 84' MOD, 70-98 minutes
- 50 mix, 40 orifice: 73' MOD, 70-98 minutes

What's in the Bag?

- Assume 40 mix, 40 orifice.
- VO_2 - O_2 Usage by diver.
 - .60 l./min. hovering -
 - .75 - 1.00 l./min. noodling: $\text{FO}_2 = .35$ to $.33$
 - 1.25 l./min (moderate exertion): $\text{FO}_2 = .31$
 - 2.00 l./min working your tail off: $\text{FO}_2 = .25$
- Set computer based on what you think will be in the bag, conservatively.

Bailout

- Stuff happens
 - When in doubt, bail out.
- Can run most RBs in open circuit mode.
- Most CCRs can be run in SCR mode.
- Also carry open circuit pony.

Diving With a Rebreather Buddy

- Know what bubbles are OK
- If you need air, take the reg from their pony
- Stay back and don't scare the critters

Local Sources

- Equipment and sorb
 - Any Water Sports, San Jose
 - Marin Skindiving, San Rafael
 - Manta Ray Dive Center, Monterey (RSN)
- Fills: any partial pressure fill
 - Manta Ray
 - Any Water Sports
 - ...
- Instruction
 - Phil Sammet
 - ??

