Chris Braissant

SDI Equipment Specialist

Ban’s Diving Resort

Introduction

Introduction

Overview

Overview

The aim of the course is to see and understand the principles of operation of the diving equipment
The course will cover various subject as maintenance and repair of regulators, valves, BCD's, cylinders and dry suit.

Introduction

Paperwork

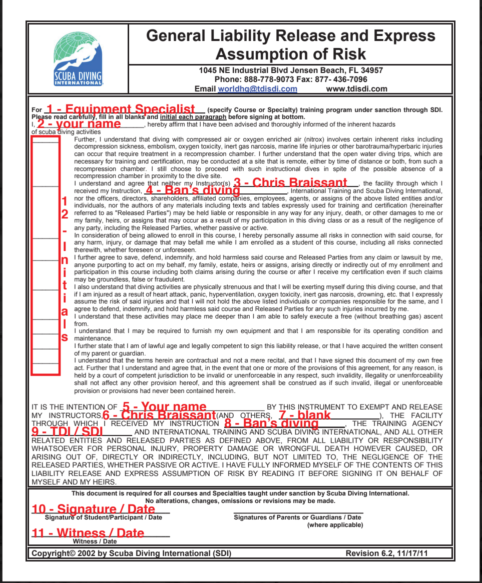
Paperwork

Liability Release and Express Assumption of Risk
Medical Statement

Introduction

Liability Release

Liability Release



General Liability Release and Express Assumption of Risk

1045 NE Industrial Blvd Jensen Beach, FL 34957
Phone: 888-778-9073 Fax: 877- 436-7096
Email worldhq@tdisdi.com www.tdisdi.com

For 1 - Equipment Specialist (specify Course or Specialty) training program under sanction through SDI.
Please read carefully, fill in all blanks and initial each paragraph before signing at bottom.

I, 2 - your name, hereby affirm that I have been advised and thoroughly informed of the inherent hazards of scuba diving activities

12 - Initials

Further, I understand that diving with compressed air or oxygen enriched air (nitrox) involves certain inherent risks including decompression sickness, embolism, oxygen toxicity, inert gas narcosis, marine life injuries or other barotrauma/hyperbaric injuries can occur that require treatment in a recompression chamber. I further understand that the open water diving trips, which are necessary for training and certification, may be conducted at a site that is remote, either by time of distance or both, from such a recompression chamber. I still choose to proceed with such instructional dives in spite of the possible absence of a recompression chamber in proximity to the dive site.

I understand and agree that neither my Instructor(s) 3 - Chris Braissant, the facility through which I received my Instruction, 4 - Ban's diving, International Training and Scuba Diving International, nor the officers, directors, shareholders, affiliated companies, employees, agents, or assigns of the above listed entities and/or individuals, nor the authors of any materials including texts and tables expressly used for training and certification (hereinafter referred to as "Released Parties") may be held liable or responsible in any way for any injury, death, or other damages to me or my family, heirs, or assigns that may occur as a result of my participation in this diving class or as a result of the negligence of any party, including the Released Parties, whether passive or active.

In consideration of being allowed to enroll in this course, I hereby personally assume all risks in connection with said course, for any harm, injury, or damage that may befall me while I am enrolled as a student of this course, including all risks connected therewith, whether foreseen or unforeseen.

I further agree to save, defend, indemnify, and hold harmless said course and Released Parties from any claim or lawsuit by me, anyone purporting to act on my behalf, my family, estate, heirs or assigns, arising directly or indirectly out of my enrollment and participation in this course including both claims arising during the course or after I receive my certification even if such claims may be groundless, false or fraudulent.

I also understand that diving activities are physically strenuous and that I will be exerting myself during this diving course, and that if I am injured as a result of heart attack, panic, hyperventilation, oxygen toxicity, inert gas narcosis, drowning, etc. that I expressly assume the risk of said injuries and that I will not hold the above listed individuals or companies responsible for the same, and I agree to defend, indemnify, and hold harmless said course and Released Parties for any such injuries incurred by me.

I understand that these activities may place me deeper than I am able to safely execute a free (without breathing gas) ascent from.

I understand that I may be required to furnish my own equipment and that I am responsible for its operating condition and maintenance.

I further state that I am of lawful age and legally competent to sign this liability release, or that I have acquired the written consent of my parent or guardian.

I understand that the terms herein are contractual and not a mere recital, and that I have signed this document of my own free act. Further that I understand and agree that, in the event that one or more of the provisions of this agreement, for any reason, is held by a court of competent jurisdiction to be invalid or unenforceable in any respect, such invalidity, illegality or unenforceability shall not affect any other provision hereof, and this agreement shall be construed as if such invalid, illegal or unenforceable provision or provisions had never been contained herein.

IT IS THE INTENTION OF 5 - Your name BY THIS INSTRUMENT TO EXEMPT AND RELEASE MY INSTRUCTORS, 6 - Chris Braissant (AND OTHERS, 7 - blank), THE FACILITY THROUGH WHICH I RECEIVED MY INSTRUCTION 8 - Ban's diving, THE TRAINING AGENCY 9 - TDI / SDI AND INTERNATIONAL TRAINING AND SCUBA DIVING INTERNATIONAL, AND ALL OTHER RELATED ENTITIES AND RELEASED PARTIES AS DEFINED ABOVE, FROM ALL LIABILITY OR RESPONSIBILITY WHATSOEVER FOR PERSONAL INJURY, PROPERTY DAMAGE OR WRONGFUL DEATH HOWEVER CAUSED, OR ARISING OUT OF, DIRECTLY OR INDIRECTLY, INCLUDING, BUT NOT LIMITED TO, THE NEGLIGENCE OF THE RELEASED PARTIES, WHETHER PASSIVE OR ACTIVE. I HAVE FULLY INFORMED MYSELF OF THE CONTENTS OF THIS LIABILITY RELEASE AND EXPRESS ASSUMPTION OF RISK BY READING IT BEFORE SIGNING IT ON BEHALF OF MYSELF AND MY HEIRS.

This document is required for all courses and Specialties taught under sanction by Scuba Diving International.
No alterations, changes, omissions or revisions may be made.

10 - Signature / Date
Signature of Student/Participant / Date

Signatures of Parents or Guardians / Date (where applicable)

11 - Witness / Date
Witness / Date

 Revision 6.2, 11/17/11

1. Equipment Specialist
2. Your name
3. Instr.: Chris Braissant
4. Facility: Ban's diving
5. Your name
6. Instr.: Chris Braissant
7. Facility: Ban's Diving
8. - blank -
9. Training agency: TDI/SDI
10. Signature and date
11. Witness signature and date
12. Your initials

Basic Theory

Basic Theory

Units Conversion

Units systems

The two most common units system used worldwide are:

- The International System of Units (or metric system)
- The British Imperial System (USA, UK, Myanmar)

International System of Units

The metric system is based on seven independant SI units.
Every other quantities are derivated from those seven SI units.

Base quantity	Unit	Symbol
Length	meter	[m]
Mass	kilogram	[kg]
Time	second	[s]
Electric current	Ampere	[A]
Temperature	Kelvin	[K]
Amount of substance	mole	[mol]
Luminous intenstiy	candela	[cd]

Length

SI Units:

$$1[mm] \xrightarrow{x10} 1[cm] \xrightarrow{x10} 1[dm] \xrightarrow{x10} 1[m]$$

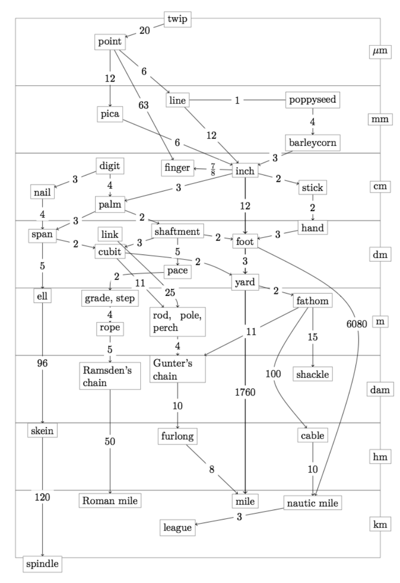
Imperial Units:

$$1[inch] \xrightarrow{x12} 1[foot] \xrightarrow{x3} 1[yard] \xrightarrow{x1760} 1[mile]$$

Conversion:

$$1[inch] = 2.54[cm]$$
$$1[foot] = 30.48[cm]$$
$$1[yard] = 0.914[cm]$$
$$1[mile] = 1.6[km]$$

SI vs Imperial



Area

SI:

$$1m \times 1m = 1[m^2]$$
$$1cm \times 1cm = 1[cm^2]$$

Imperial:

$$1'' \times 1'' = 1[sq\ in]$$

Conversion:

$$1[sq\ in] = 2.54 \times 2.54 = 6.45[cm^2]$$

Volume

SI Units:

$$1[m] \times 1[m] \times 1[m] = 1[m^3]$$
$$1[dm] \times 1[dm] \times 1[dm] = 1[dm^3] = 1 liter$$
$$1[cm] \times 1[cm] \times 1[cm] = 1[cm^3]$$

Imperial:

$$1[inch] \times 1[inch] \times 1[inch] = 1'' \times 1'' \times 1'' = 1[cu\ in]$$
$$1[foot] \times 1[foot] \times 1[foot] = 1' \times 1' \times 1' = 1[cu\ ft]$$

Conversion:

$$1[cu\ ft] = 30.48 \times 30.48 \times 30.48 = 28.3[dm^3] = 28.3 liter$$

Mass and weight

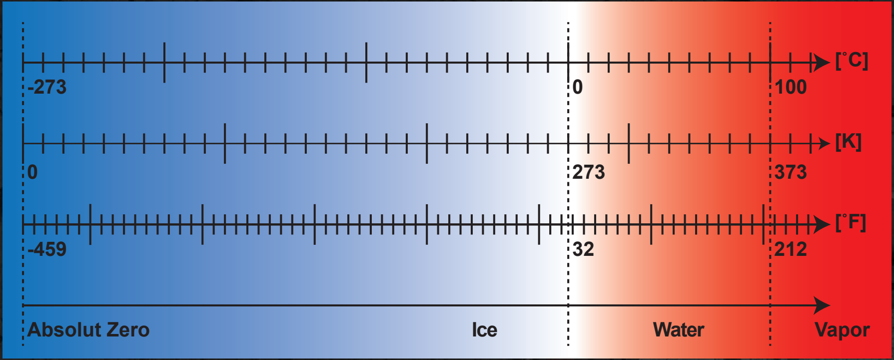
Mass

$1kg$	$\approx 2.2lbs$
$1lbs$	$\approx 0.45kg$
$1m^3$	$1000kg$ of fresh water
	$1030kg$ of salt water
	$1.239kg$ of air
$1kg$	$\approx 9.81N$

Pressure

Pascal		
$1 Pa$	$1 Newton/m^2$	$0.1 kg/m^2$
Bar		
$1 bar$	$100'000 Pa$	$0.1 MPa$
$1 bar$	$0.981 kg/cm^2$	$\approx 1 kg/cm^2$
PSI		
$1 PSI$	$1 lbs/sqi$	
$1 PSI$	$0.45 kg/6.45 cm^2$	$0.068 bar$
$\rightarrow$	$1 bar$	$14.5 PSI$

Temperature



Formulas:

$$[^\circ C] = [K] - 273 \qquad [K] = [^\circ C] + 273$$

$$[^\circ C] = \frac{5}{9} * ([^\circ F] - 32) \qquad [^\circ F] = \frac{9}{5} * [^\circ C] + 32$$

Basic Theory

Properties of gases

Composition of the air

78.084%	Nitrogen (N_2)
20.946%	Oxygen (O_2)
0.934%	Argon (Ar)
0.033%	Carbon Monoxide (CO)
0.003%	Other gases

18.18ppm	Neon (Ne)
5.24ppm	Helium (He)
1.14ppm	Krypton (Kr)
0.09ppm	Xenon (Xe)

Breathing gases

Nitrogen (N_2)	Narcotic
Oxygen (O_2)	Toxic at high ppO_2
Helium (He)	Distortion of voice
Neon (Ne)	Dense, long decompression, expensive
Hydrogen (H)	Explosive with more than 4% of Oxygen
Argon (Ar)	Narcotic, dense, hard to breathe
Xenon (Xe)	Narcotic, anesthetic, expensive

Gas mixing

Nitrox	Nitrogen and Oxygen
Heliox	Helium and Oxygen
Trimix	Oxygen, Helium and Nitrogen (ex; TMX 18/45)
Heliair	Helium and Air ("Poor man's trimix")
Hydrox	Hydrogen and Oxygen
Hydreliox	Hydrogen, Helium and Oxygen

Nitrogen (N_2)

- Diatomic (N_2)
- Physiological inert
- High Density
  - High respiratory effort at depth
- Narcotic effect
  - At high partial pressure ($ppN_2 > 3.2$)
- Decompression sickness
  - Unmetabolized by the body - Bubble formation
- Doesn’t dissolve in water
  - but easily in grease and oil (fat tissue)

Nitrogen (N_2)

- Decompression sickness
  - I Pain
  - II CNS (Central Nervous System) and pain
  - III Severe type I and II
    Suffocation
    Isobaric Counter Diffusion (Trimix)
  - IV Long term exposure
    "Osteonecrosis" = bones’ death

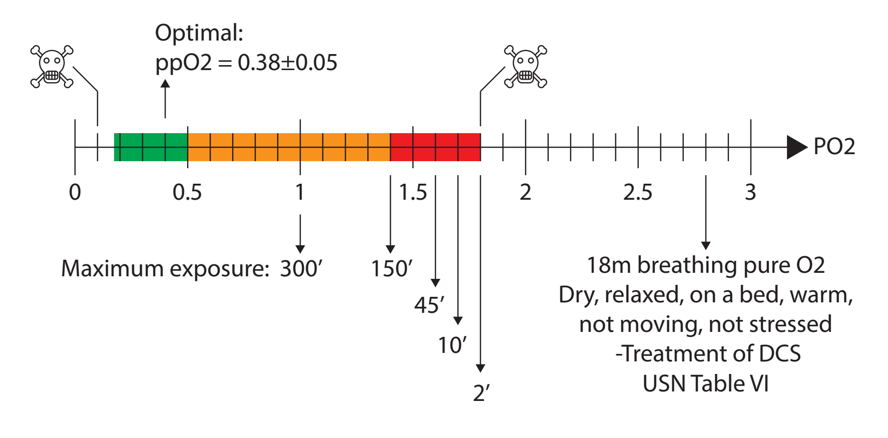
Oxygen O_2

- Diatomic (O_2)
- Support combustion
  - Violently at high pressure
- Essentiel for life
  - Not enough = Hypoxia
  - Too much = Hyperoxia
- Odorless, colorless, tasteless
- NON-flammable

Oxygen O_2

Anoxic	No oxygen at all
Hypoxic	Lower than normal partial pressure of oxygen
Normxic	Normal partial pressure of oxygen
Hyperoxic	Higher partial pressure of oxygen

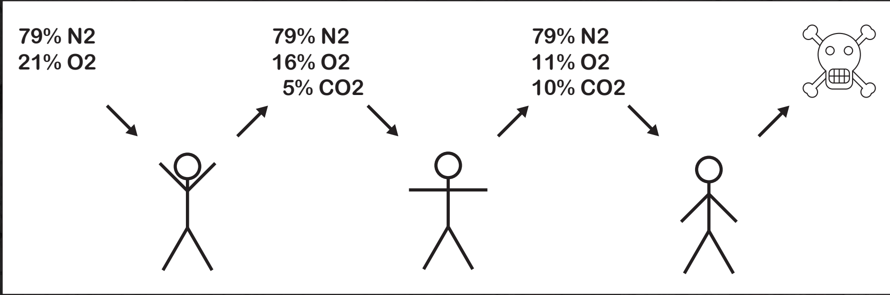
Oxygen Exposure



Carbon Dioxide (CO_2)

- Waste product of the metabolism
- 5% respiratory problem
- 10% respiratory distress
- Enhanced by "Dead space"
- 1% of CO_2 in the air double CO_2 level in the blood at 40m

Carbon Dioxide (CO_2)



Carbon Monoxide (CO)

- Extremely toxic
- Odorless, colorless, tasteless
- Product of combustion
  - Poor compressor lubrication
  - Poor compressor positioning
- Hemoglobin bounds 300x easier with CO than with O_2

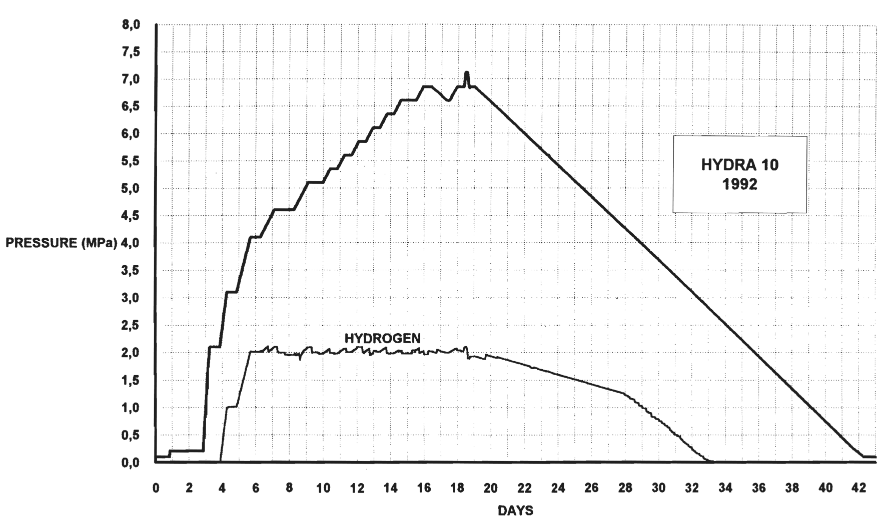
Helium (*He*)

- Substitut for Nitrogen N_2 in deep diving
- Lower respiratory effort
- Reduce narcosis
- Rare gas = expensive!
- High thermal conductivity ($\neq$dry suit)
- HPNS:
  High Pressure Neurological Syndrom
- Special dive tables compulsary
- Limited in recreational diving (price)
- Rebreather more economical

COMEX Hydra X (1992)

- Theo Mavrostomos
- Depth of -701m in recompression chamber
- Hydreliox 0.5%O_2 / 71.5%He / 28%H_2
- Duration
  - 4 weeks of preparation pre-dive
  - 2 days at 10m
  - 13 days of compression to -675m
  - 3 days between -650 and -675m with a peak to -701m
  - 24 days of decompression

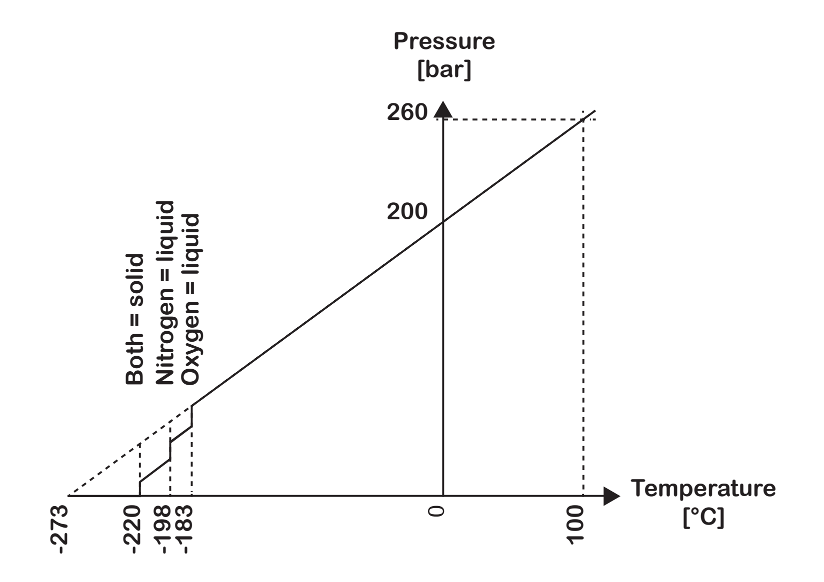
COMEX Hydra X (1992)



Temperatures

$-183°C$	Oxygen's boiling point
$-196°C$	Nitrogen's boiling point
$-220°C$	Oxygen and Nitrogen are solid
$-273°C$	Absolut Zero (No particule is moving)

Temperatures



Basic Theory

Gas laws

Gas laws

Boyle-Mariotte's law

$$P \propto \frac{1}{V} \qquad (T = constant)$$

Charles' law

$$V \propto T \qquad (P = constant)$$

Gay-Lussac's law:

$$P \propto T \qquad (V = constant)$$

Ideal gas law

$$\frac{P_1 x V_1}{T_1} = \frac{P_2 x V_2}{T_2}$$

Gas laws

Dalton's law

$$P = PP1 + PP2 + PP3 + ...$$

Joule-Thomson effect

- Phenomenon in which the temperature increases when a gas undergoes adiabatic compression

Henry's law

- At constant temperature and at saturation, the amount of gas dissolve in a liquid is proportional to the partial pressure exerted by the gas on the liquid.

Regulators

Regulators

Design requirements

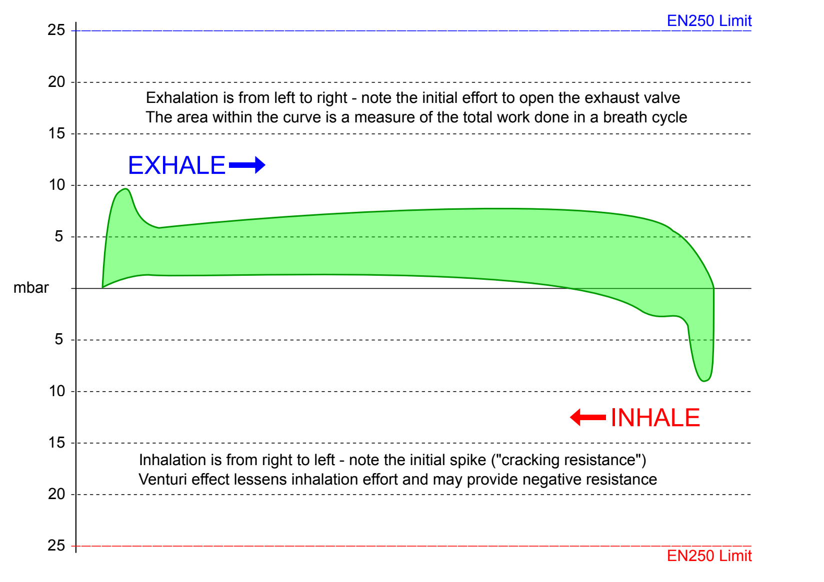
Variables

- Change in ambiant pressure (depth)
- Change in respiratory volume
- Increase in breathing rate
- Increase in air density
- Friction losses
- Tendency to freeze (Joules-Thompson effect)

Standard EN250

Depth:	0-65m
Respiratory rate:	0-25 inspirations/min
Respiratory volume:	2.5 liters
Respiratory cycle:	Sinusoidale
Inhalation resistance:	25 mbar (10 inch of water)
Exhalation resistance:	25 mbar (10 inch of water)
Work of breathing:	3.0 joules per litre
Storage temperature:	$-40^{\circ}C$ to $80^{\circ}C$
Working temperature:	
1. Cold water	$0^{\circ}C$ to $50^{\circ}C$
2. Warm water	$10^{\circ}C$ to $50^{\circ}C$
Pressure:	$35-200bar$ (A-Clamp)
	$35-300bar$ (DIN)

Work of breathing



Types of compensation

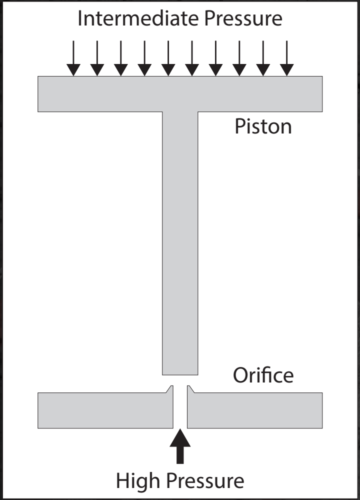
- Compensation of ambiant pressure
  - Linked to the depth
  - Increase the intermediate pressure
  - All regulators are made that way
- Compensation of pressure loss
  - Linked to the pressure in the tank
  - Reduced pressure in the cylinder causes a decrease in the intermediate pressure
  - Compensation to provide a stable pressure
  - Only some regulators (Balanced regulators)

Regulators

Principle

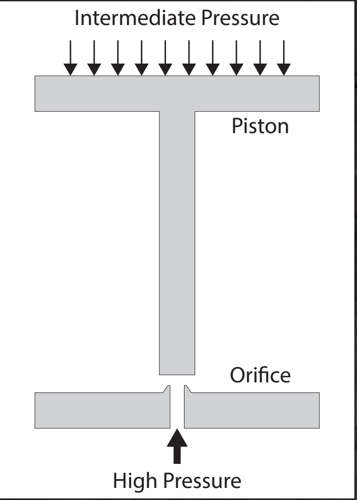
Principle

The force exerted on an object depends on the surface and the pressure applied. To create a stable system, the forces at each end of the piston must be identical.



Principle

When the intermediate pressure is high enough, the piston will close the orifice and the system will be stable.

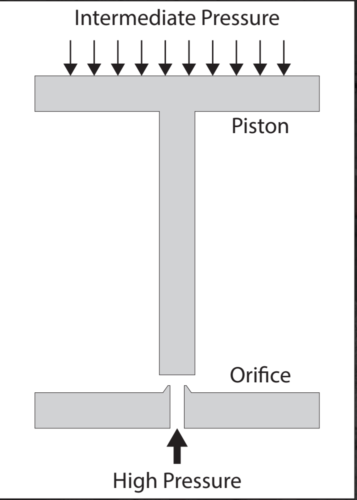


Principle

Definitions:

$$D = Diameter[cm]$$
$$S = Surface[cm^2] = \frac{\pi * D^2}{4}$$

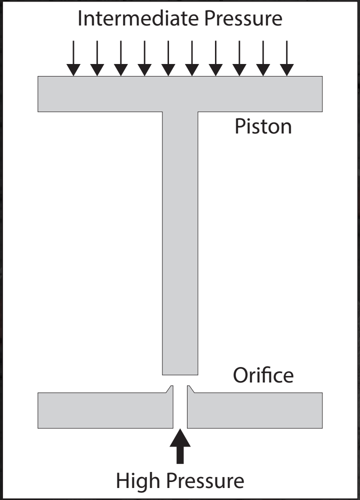
$$P = Pressure[bar]$$
$$F = Force[{}^{kg}/_{cm^2}] = P * S$$



Principle

Orifice:

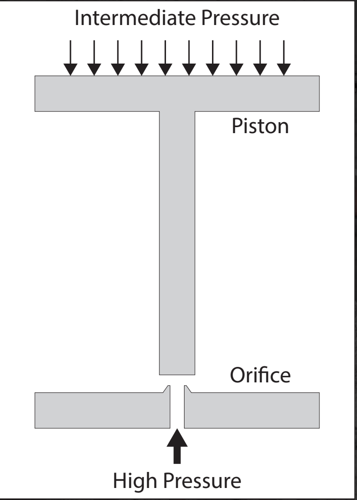
$$D_{orifice} = 0.447[cm]$$
$$S_{orifice} = \frac{\pi * 0.447^2}{4} = 0.157[cm^2]$$
$$F_{orifice} = 200 * 0.157 = 31.4[{}^{kg}/_{cm^2}]$$



Principle

Piston:

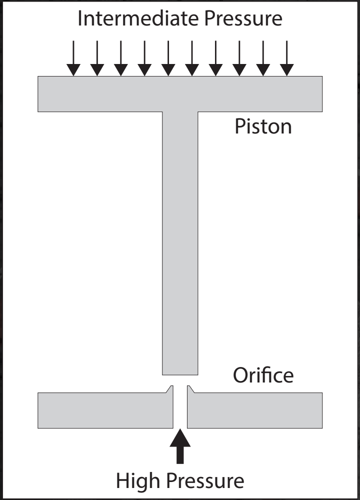
$$
\begin{aligned}
D_{piston} &= 2[cm] \\
S_{piston} &= \frac{20 * D_p^2}{4} \\
&= 3.14[cm^2] \\
F_{piston} &= F_{orifice} \\
P_{piston} &= \frac{F_p}{S_p} \\
&= \frac{31.4}{3.14} \\
&= 10[bar]
\end{aligned}
$$



Principle

Problem:

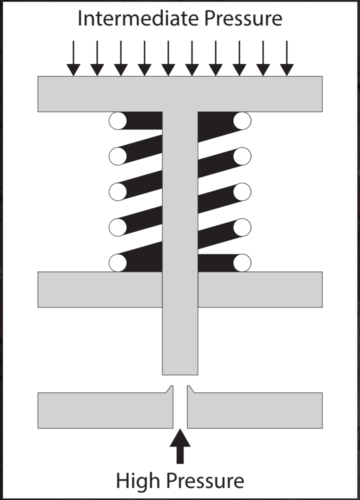
- When the pressure in the tank decrease, the intermediate pressure will drop.
- This system in a pressure divider (ratio 1:20) and not a regulator.



Principle

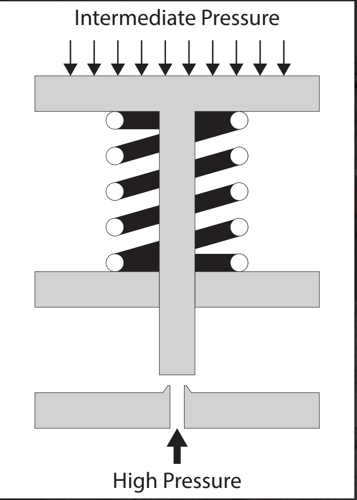
To compensate the pressure drop in the tank, a spring is add to the system

$$F_{piston} = F_{orifice} + F_{spring}$$



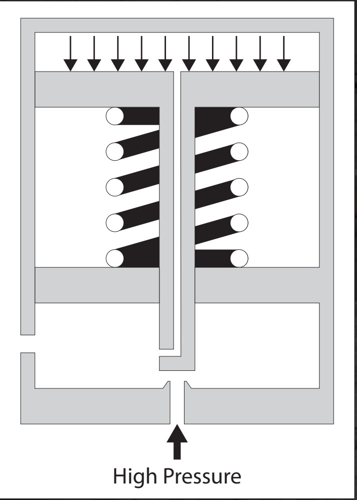
Principle

The intermediate pressure can now be adjusted by changing the caracteristics of the spring.

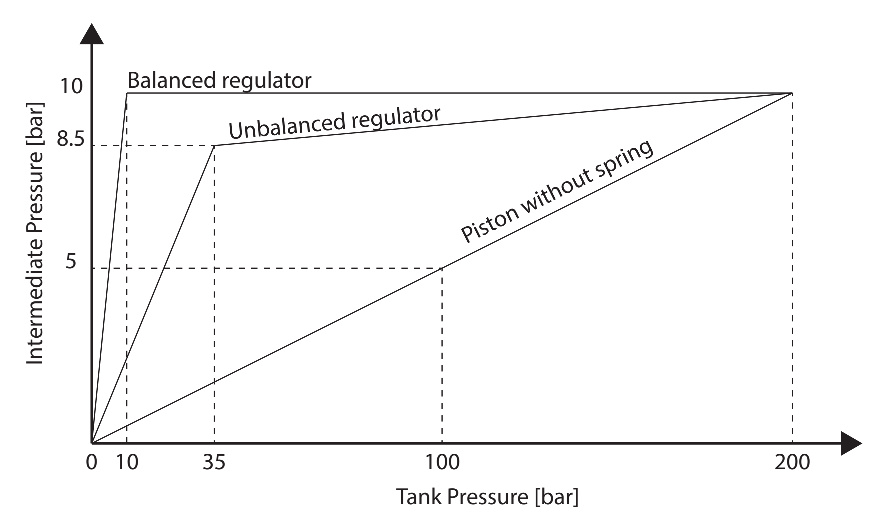


Principle

Finally, the piston is drilled to allow the air to flow through to the other side.



Principle


Balanced regulator
Unbalanced regulator
Piston without spring
10
8.5
5
Intermediate Pressure [bar]
0
10
35
100
200
Tank Pressure [bar]

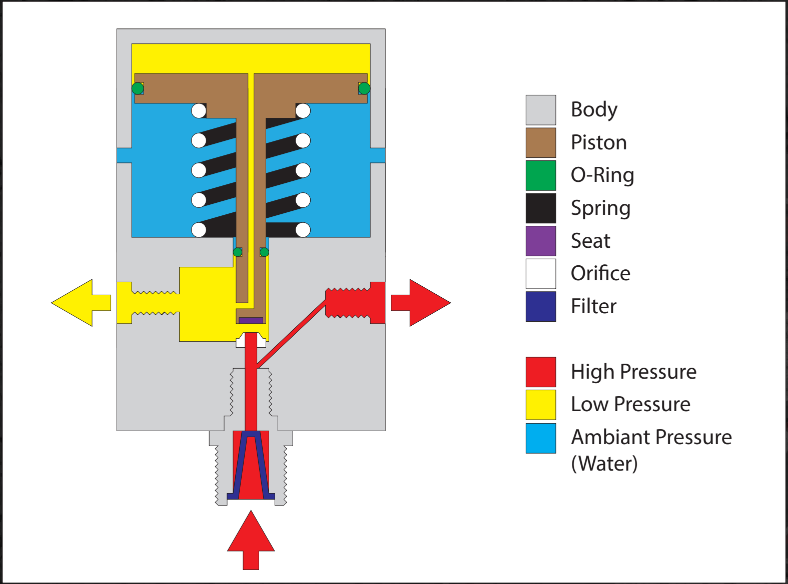
Regulators

First stage

Design types

- Unbalanced piston
- Balanced Piston
- Unbalanced diaphragm
- Balanced diaphragm

Unbalanced piston



Unbalanced piston

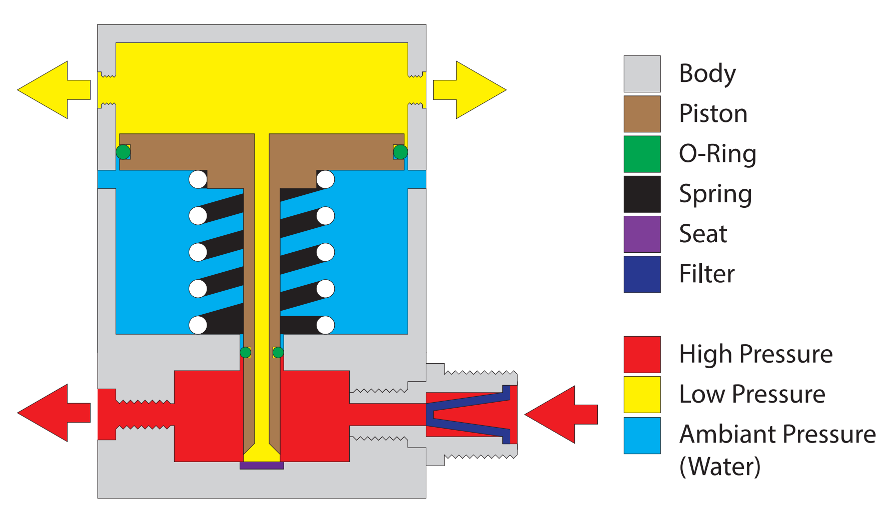
Unbalanced piston

- Pros
  - Cheap
  - Easy to service
  - Strong and durable
  - Perfect for dive school
- Cons
  - Limited performances

Unbalanced piston

- Models
  - Aqualung Calypso
  - Scubapro MK2
  - US Divers Conshelf

First stage


Body
Piston
O-Ring
Spring
Seat
Filter
High Pressure
Low Pressure
Ambiant Pressure (Water)

Balanced piston

Balanced piston

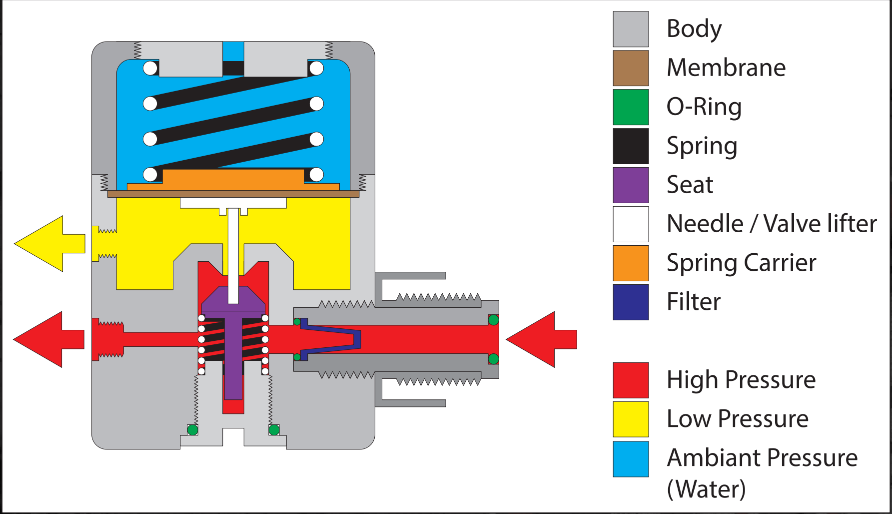
Balanced piston

- Pros
  - Safe and reliable
  - Excellent performance
  - Strong
- Cons
  - Expensive
  - Prone to freeze ("flow-through" piston)
  - Complicated to service

Balanced piston

- Models
    - Halcyon H-75P
    - Scubapro MK20, MK25

Unbalanced diaphragm



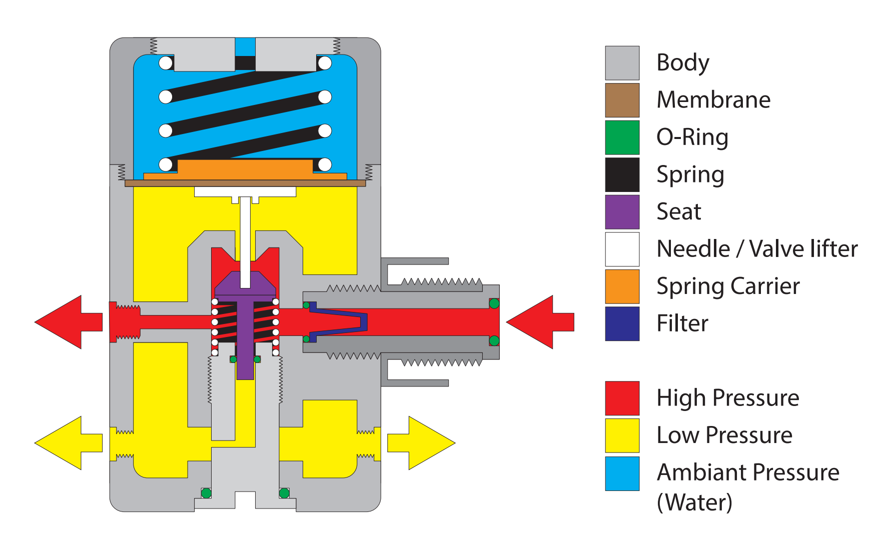
Unbalanced diaphragm

- Not common
- Pros
  - Increase in intermediate pressure when cylinder pressure drops
- Cons
  - Needs a second stage which can handle a higher intermediate pressure
  - Harder to breathe at the begining of the dive

Unbalanced diaphragm

- Models
  - None availaible on the market

Balanced diaphragm



Balanced diaphragm

Balanced diaphragm

Balanced diaphragm

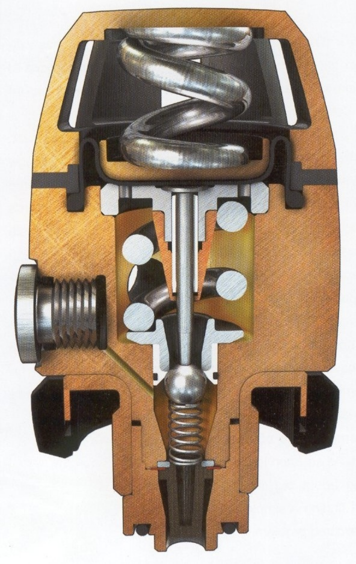
- Most common regulator
- Pros
  - Simple but effective
  - Easily set up for cold water
- Cons
  - Doesn't like being flooded

Balanced diaphragm

- Models
  - Apeks (All)
  - Aqualung Legend, Glacia,...
  - Halcyon H-50D
  - Mares Abyss, Prestige,...
  - Scubapro MK11, MK17
  - Poseidon Jetstream

Balanced diaphragm

- Poseidon Xstream
  - The seat is replaced by a ball closing the orifice
  - The needle act on the ball the same way as on the seat
  - A spring hold the ball in place



First stage options

- Anti-freeze system
  - Ambiant pressure filled with grease
  - Cap filled with grease
  - Diaphragm filled with oil
  - Diaphragm with piston or "load transmitter" (Most common)
  - Dry ambiant pressure by "Dry bleed" (Controled leak of the first stage)
  - "Condom and vodka"!

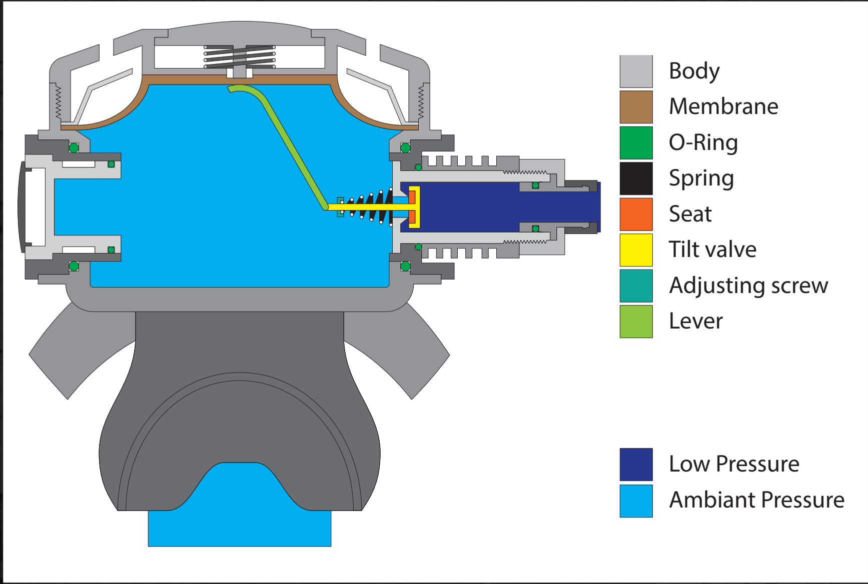
Regulators

Second Stages

Design types

- Upstream valve
- Unbalanced downstream
- Balanced downstream
- Servo or pilot valve

Upstream valve



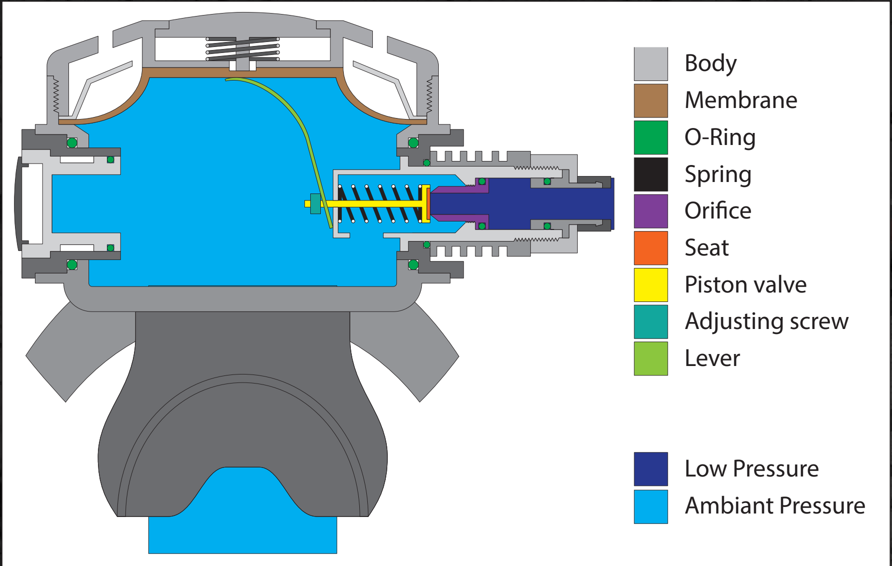
Upstream valve

- Pros
  - Simple
- Cons
  - Upstream design
    Need a pressure relief valve (PRV)
  - Limited performances

Upstream valve

- Models
    - None availaible on the market

Unbalanced downstream



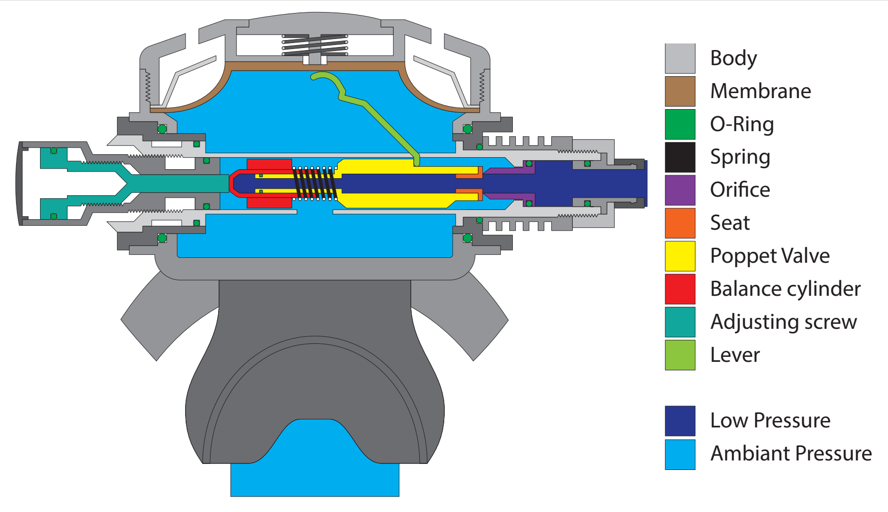
Unbalanced downstream

- Pros
  - Cheap
  - Easy to service
  - Perfect for dive school
  - Downstream design
    (Act as a pressure relief valve)
- Cons
  - Limited performances

Unbalanced downstream

- Models
  - Aqualung Calypso
  - Mares Prestige
  - Scubapro R095, R195,...
  - US Divers Conshelf

Balanced downstream



Balanced downstream

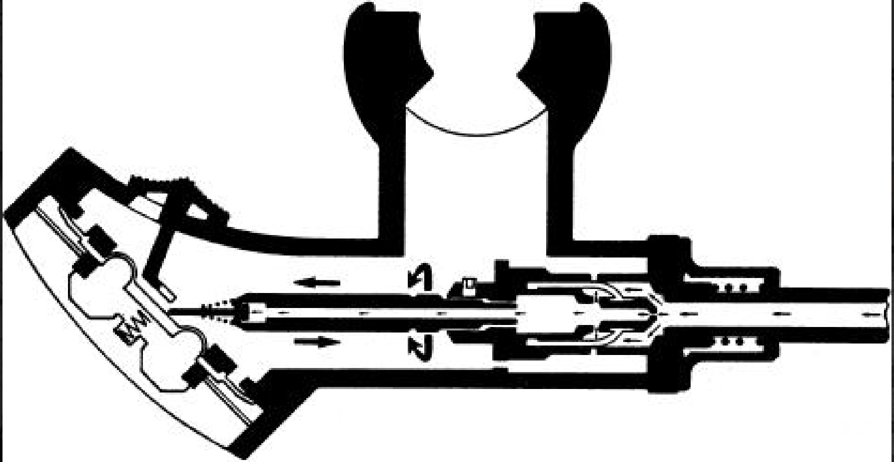
Balanced downstream

- Pros
  - Safe and efficient
  - Good performances
  - Easily adjustable
- Cons
  - Expensive
  - Complicated to service

Balanced downstream

- Models
  - Apeks (all)
  - Aqualung Legend, Glacia
  - Scubapro G250, S600, A700,...

Servo or pilot valve



Servo or pilot valve

- Pros
  - Efficient
  - Good performances
  - Don't freeze
    (no metal part are moving)
- Cons
  - Complicated
  - Upstream design
    Need a pressure relief valve
  - high inhalation resistance

Servo or pilot valve

- Models
    - Poseidon Jetstream and Xstream

Second stage options

- Venturi effect
  - Reduce respiratory effort
  - Tendency to induce a freeflow
  - Deflector inside the case modifiying the air flow

Inflators

Inflators

Shrader valve

Shrader valve

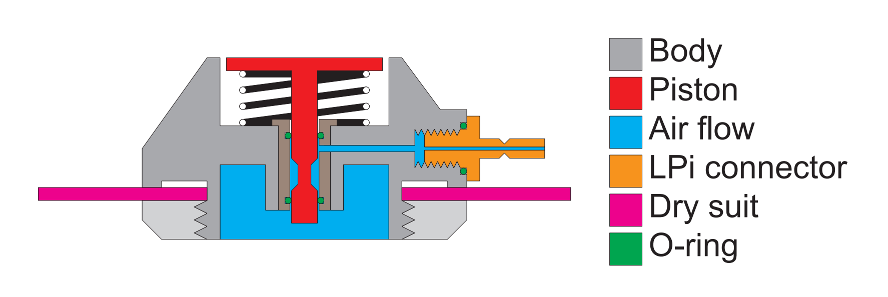
The inflator hose are using a Schrader valve.
A small upstream valve that open when it is pushed.
When the hose is disconnected, the pressure close the valve and avoid any leak.
Same valve used for the bike tires!

Inflators

Dry suit

Dry suit

Dry suit



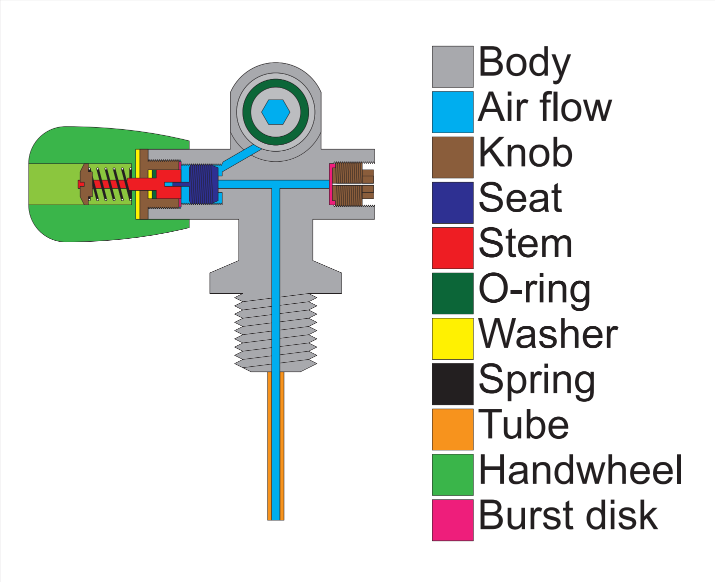
Valves

Valves

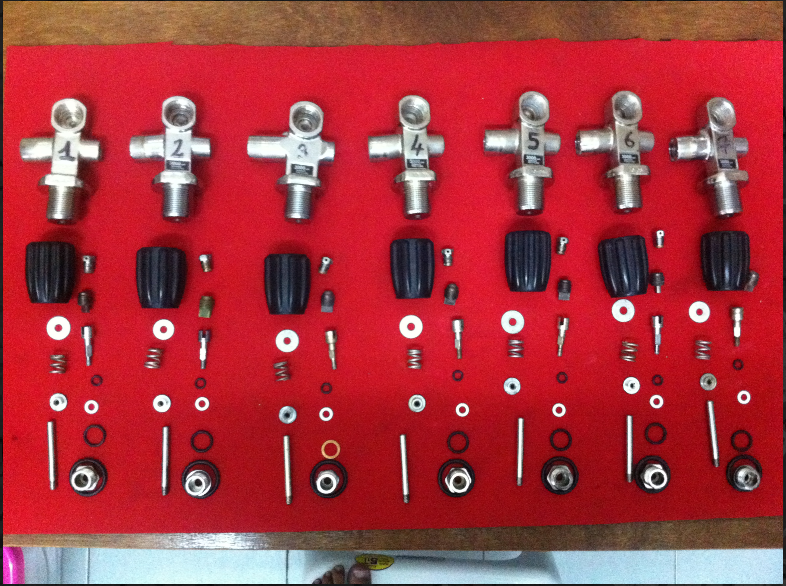
Design

K-Valve with burst disc

K-Valve with burst disc

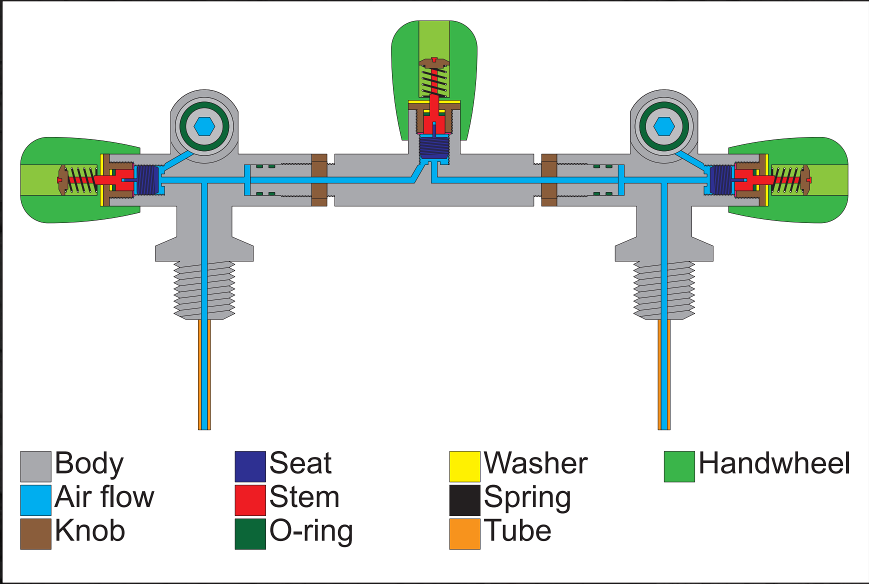


K-Valve with burst disc



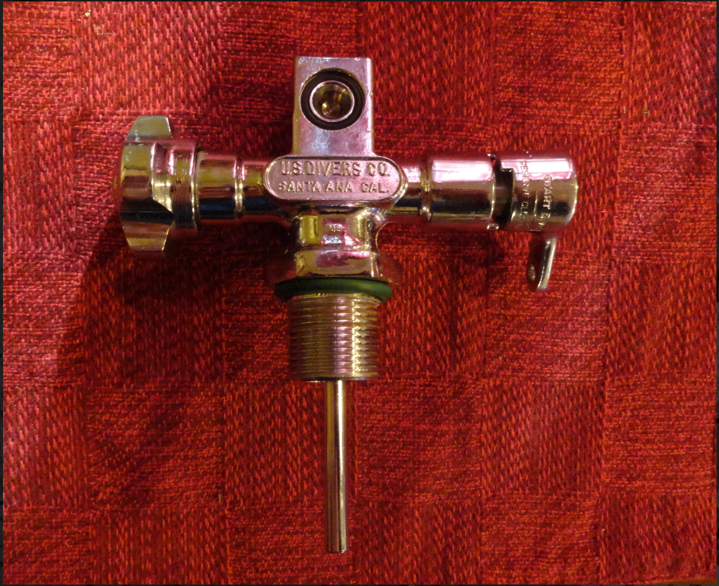
Manifold

Manifold

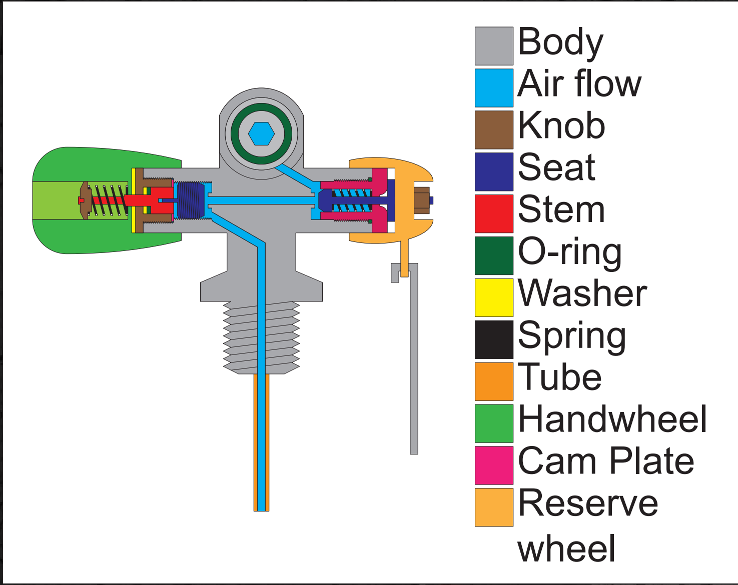

Body
Air flow
Knob
Seat
Stem
O-ring
Washer
Spring
Tube
Handwheel

Introduction
Basic Theory
Regulators
Inflators
Valves
Design
Output
Tank threads
Cylinders

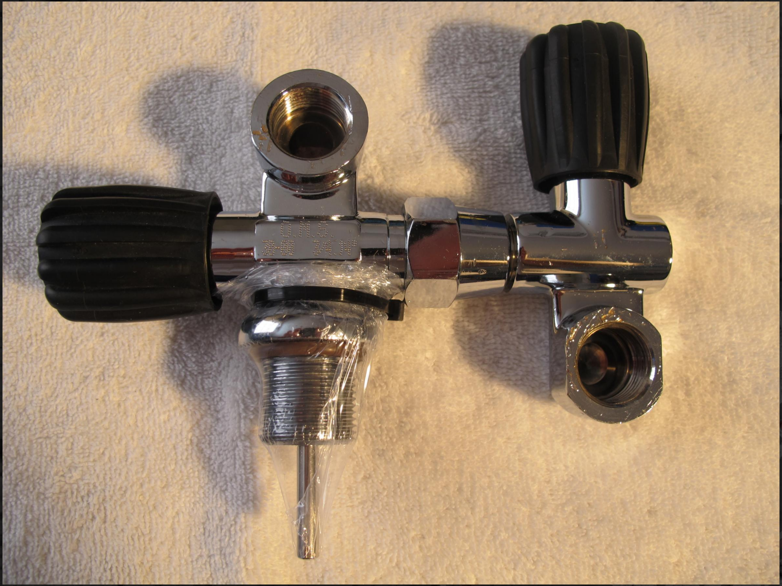
J-Valve



J-Valve


Body
Air flow
Knob
Seat
Stem
O-ring
Washer
Spring
Tube
Handwheel
Cam Plate
Reserve wheel

H-Valve



Y-Valve

J-Valve with manifold

Valves

Output

A-clamp

- Yoke, Int, A-Clamp
- O-ring pinched between the valve and the reg
- Maximum pressure of 232bar

DIN

- DIN $G^5/_8$" $(22.9mm)$
- O-ring compressed inside the valve
- Screwed connection, so extremely strong
- 5 threads for 232 bar
- 7 threads for 300 bar

Insert

- Convert a DIN to Yoke
- Insert screwed inside a DIN
- Numerous types of valves and insert
  Compatibility not guarranted

DIN M26

- DIN valve with a bigger diameter (26*mm*)
- Used for oxygen or nitrox tanks

CGA540

- Valve used for pure oxygen tanks
- Connectic metal to metal (brass)
- No o-ring
- Wrench necessary to tighten correctly and avoid any leak

Valves

Tank threads

Tank threads

Europe:

- $M25 * 2mm$ DIN (Deutsche Industrial Norm)
  ø$= 25mm$, $2mm$ between each threads

- $M18 * 1.5mm$ DIN (Deutsche Industrial Norm)
  ø$= 18mm$, $1.5mm$ between each threads

- $G^3/_4 * 14$ BSP (British Standard Pipe)
  ø$= 26.4mm$, 14 threads per inch

USA (and worldwide):

- $^3/_4$" $* 14$ NPSM
  (National Pipe Straight Mecanical)
  ø$= 26.4mm$, 14 threads per inch

Tank threads

ATTENTION

- British *G*3/4” and American 3/4” NPSM are really close but not compatible
- The shape of the threads are not the same

Cylinders

Cylinders

Material

Aluminium alloy

- Pros:
    - Don’t rust!
    - Don’t need to be painted
- Cons
    - Positively buoyant when empty
    - Galvanic corrosion with brass (valve) and steel (cam bands)
    - Maximum temperature: $150^{\circ}C$

Steel

- Pros:
  - Strong
  - Negatively buoyant when empty (less weight needed)
  - Higher working pressure($232bar$)
  - Lighter
  - Maximum temperature: $300°C$
- Cons:
  - Rust!!!
  - Need to be painted

Carbon fiber

- Pros:
  - High pressure ($300 bar$)
  - Light
- Cons:
  - Fragile!
  - Distinctive visual and hydrostatic inspections

Cylinders

Comparison

Comparison

Aluminium
Worthington AL80

Pressure:	$207 bar$
Volume:	$11.1 L$
Empty weight:	$14.5 kg$
Buoyancy empty:	$+1.45 kg$
Buoyancy at $200 bar$:	$-0.81 kg$

Steel
Worthington 80

Pressure:	$237 bar$
Volume:	$11.1 L$
Empty weight:	$12.7 kg$
Buoyancy empty:	$-1.36 kg$
Buoyancy at $200 bar$:	$-4.08 kg$

Aluminium
Catalina S80

Pressure:	$207 bar$
Volume:	$11.1 L$
Empty weight:	$14.2 kg$
Buoyancy empty:	$+1.85 kg$
Buoyancy at $200 bar$:	$-0.72 kg$

Aluminium
Luxfer AL80

Pressure:	$207 bar$
Volume:	$11.1 L$
Empty weight:	$14.2 kg$
Buoyancy empty:	$+1.54 kg$
Buoyancy at $200 bar$:	$-0.63 kg$