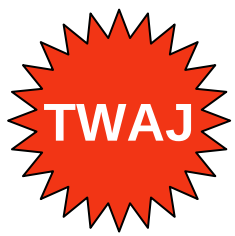
Everything You've Ever Wanted to Know About Regulators But Were Afraid to Ask

- **A Brief History of the Regulator**
- **How a Regulator Works**
- **A Buyer's Guide**
- **Care and Feeding of Your Regulator**

by John Armstrong

Caveat Listener

- Information may be simplified for ease of presentation
- You should always consult multiple sources of information before buying life support equipment
- All opinions are those of the author only – your mileage may vary
- Look for ‘The World According to John’ labels sprinkled liberally throughout this presentation



What is a SCUBA Regulator?

A device that delivers breathing gas on demand at ambient pressure

Regulator History

"Diving" came long before the regulator

- Diving bells were used as far back as the 16th century – by the 1700s, diving bells featured surface supplied air
- In 1826, Charles Anthony and John Deane patented a fire helmet that could also be used for diving
  - The first person-portable underwater system and the genesis of hard-hat diving
- 1877 – Henry Fleuss develops the first self-contained diving rig
  - Delivered a continuous flow of O2 from a compressed gas cylinder to the helmet
- 1911 – Draeger introduces its oxygen rebreather
- 1943 – Jacques Cousteau and Emile Gagnan couple a gas regulator with a demand valve to create the AquaLung – the first modern SCUBA rig

From . . .

Aqualung

The original AquaLung featured a single-stage, two hose regulator

- Gas pressure stepped directly from tank supply (HP) to ambient pressure (AMB)
- Demand diaphragm, exhaust valve located behind head

to

Regulator

Today's regulator is a single-hose 2-stage device, a design first developed by E.R. Cross in 1951

- First stage steps HP down to intermediate pressure (IP)
- Demand valve second stage delivers gas at AMB
- Demand diaphragm, exhaust valve located at diver's mouth

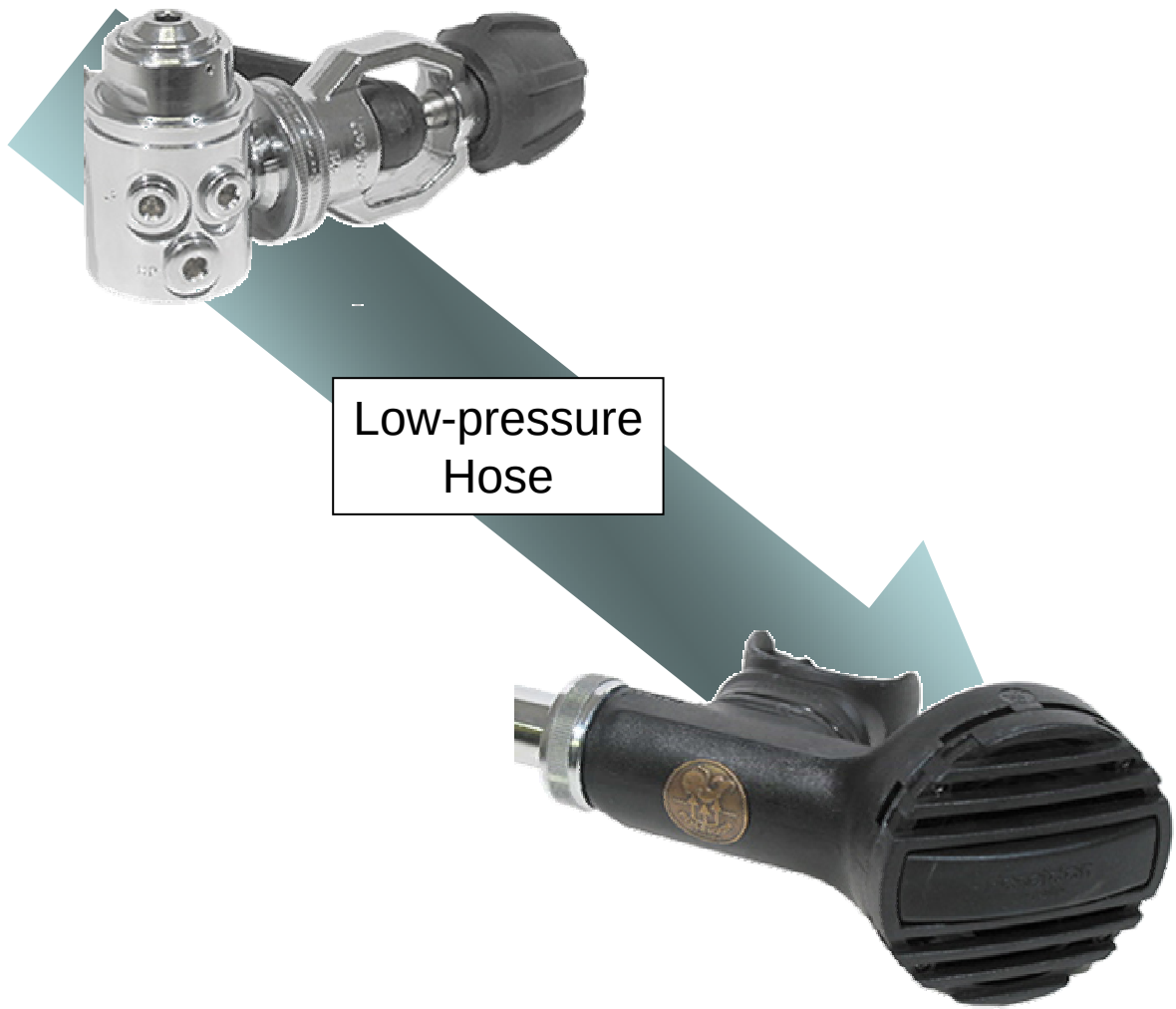
How Does a Regulator Work?

Tank Pressure
(3500psi or less)

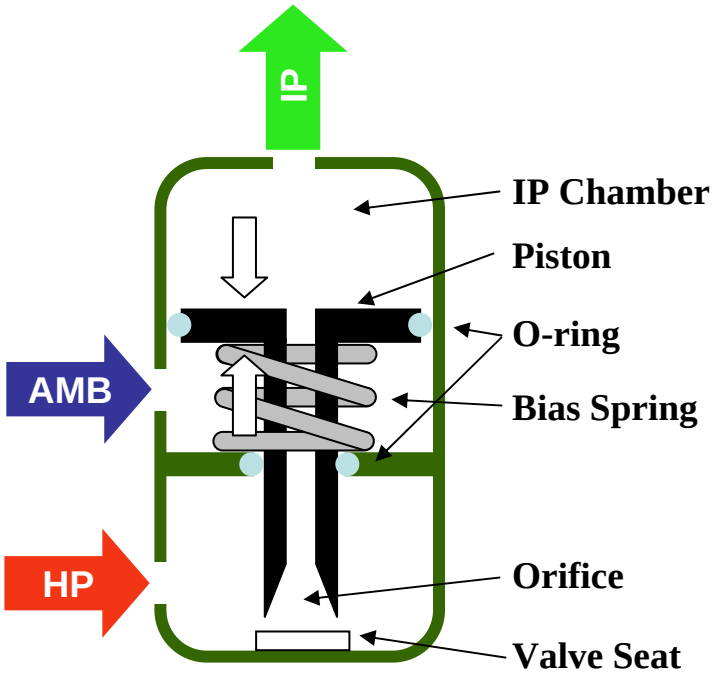
Intermediate Pressure
(ambient+130-150 psi)

Ambient Pressure
(depends on depth)

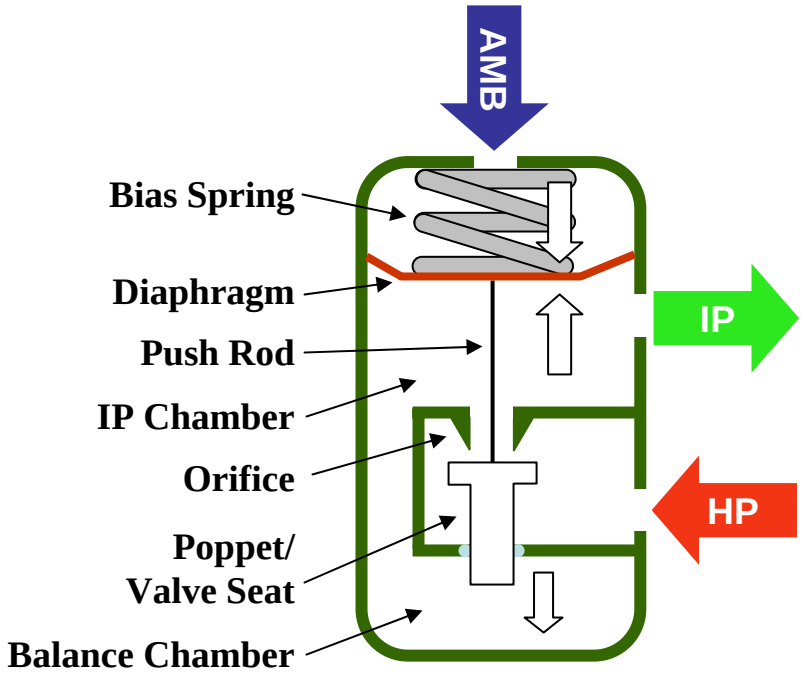
Pressure



1st Stage Design and Operation

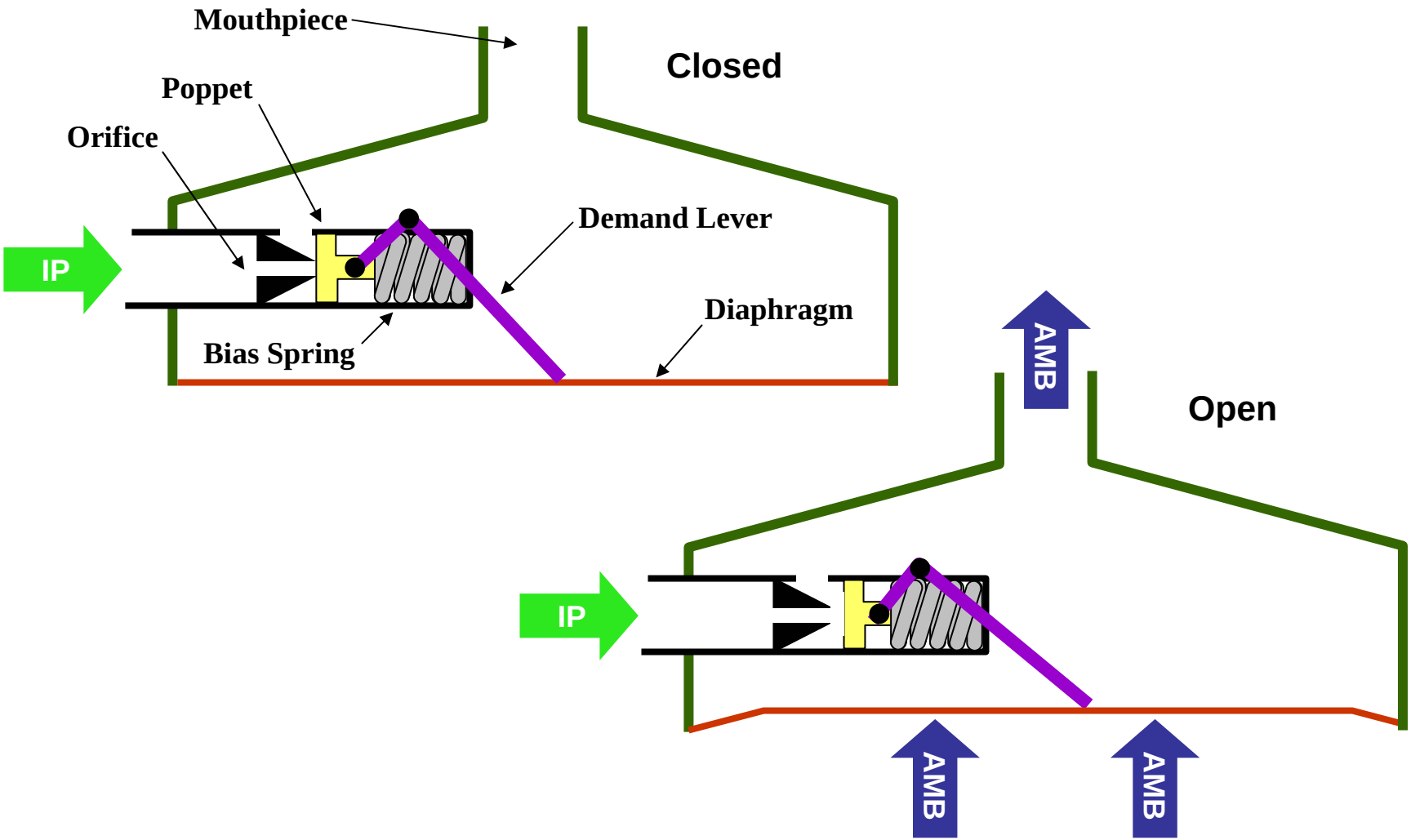


Balanced Piston
First Stage (open)



Balanced Diaphragm
First Stage (open)

2nd Stage Design and Operation



Buying a Reg – What to Look At

- Basic considerations
  - Type, Design, Performance, etc.
- Features
  - The extras you want and need
- Special needs
  - Considerations specific to <u>your</u> diving needs

There has never been a better time to buy a regulator. Today's regulators perform very well and there are many bargains to be had.

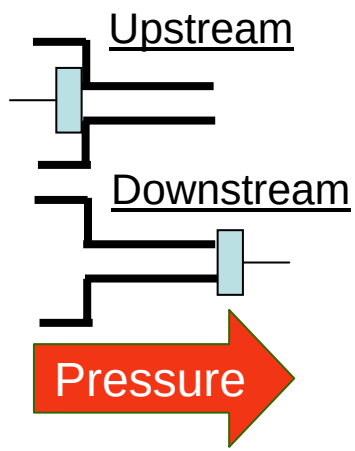
1st Stage Types

- Diaphragm vs. Piston
  - Both types can perform very well
  - Pistons are said to perform better at very low tank pressures
  - Diaphragm regulators are better suited to cold and mucky conditions
    - Environmental sealing is easier and more effective for diaphragm regulators

For diving in New England, I would never go with a piston reg, but that's just me.

Design Considerations

- Balanced vs. Unbalanced
  - A balanced regulator is one in which pressure on both sides of the valve is equalized
  - Performance is less effected by tank pressure
  - Most regulators made today are balanced
- Upstream vs. Downstream Valves
  - Positive action is required to open an upstream valve – valve is said to ‘fail closed’
  - Positive action is required to CLOSE a downstream valve – valve ‘fails open’
  - Poseidon is the only major brand that employs upstream valves



Second Stage Types

- Bottom Exhaust vs. Side Exhaust
  - Both can perform well
  - Side exhaust is directionless – a plus for a regulator that you may have to donate
  - Side exhaust can reduce bubble interference
  - Side exhaust breathes wetter than bottom exhaust
- Demand Lever vs. Servo
  - Performance is generally similar given modern lever designs
  - Servos are much more complicated and harder to service
  - People who prefer servos are very passionate about them

TWAJ

You can't go wrong here – pick what you like.

Regulator Materials

- 1st Stage
  - Bodies are typically chrome plated brass
  - Internal parts can be made of stainless steel, brass, and bronze
- 2nd Stage
  - Polycarbonate is the most common body material
  - Some second stages are still made with brass body pieces
  - Internals are usually stainless steel
- Titanium
  - Ti is lightweight, corrosion resistant and very expensive
  - There are some concerns about Ti's compatibility with high oxygen partial pressures

Titanium is a solution in search of a problem – don't waste your money

Tank Fittings

Tanks have 2 types of fitting – yoke and DIN

- Max working pressure for yoke is 3200psi
- DIN fittings are either 200 bar or 300 bar
  - A 7-thread 300 bar regulator will fit a 5-thread 200 bar tank valve but not vice versa
- DIN is a superior fitting
  - Mechanically stronger, captured o-ring
- Most regs are available with a semi-permanent refit kit
  - Temporary refit kits for yoke regs are almost always 200 bar
- It is easy to convert a DIN regulator to yoke
  - Minor disadvantages include increased weight and bulk

Yoke

DIN

DIN w/Yoke adapter

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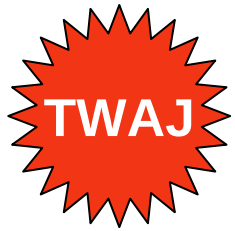
If you will ever own only one regulator, buy a 300bar DIN regulator and yoke adapter and you can't go wrong

Performance



- High performance can be taken to mean the ability to easily deliver a sufficient quantity of gas in difficult circumstances
  - Today's bargain-priced regulators would all be considered high performance by the standards of the 1980s
  - All major brand regulators will perform well for all but extreme conditions
- While there is a 'work of breathing' measure, test conditions are not standardized
- There are no standards organizations that review regulator performance and safety in a way that is relevant to recreational divers
  - U.S. Navy test are the closest – but be wary of manufacturer claims

Regulator Design Features

- Hose swivel
  - Hose swivels can help with hose routing
  - Properly located fixed hose ports are just as good
  - Swivel is a potential point of failure
- Hose fittings
  - All regulators except Apeks and Poseidon use standard hose fittings
  - Think about how many you will need
    - Most regulators have 4LP + 1HP, but not all do

Favor designs without a swivel, but do not compromise on hose routing.

Second Stage Adjustments

- Three common types:
  - Cracking pressure adjustment – how hard you have to draw before gas delivery begins
  - Venturi adjustment – controls flow performance once valve has been cracked, is also used to prevent/reduce free-flow
  - Pre-dive/Dive – used to prevent/reduce free-flow at surface

Second stage adjustments are nice to have, but many excellent regulators do not have any at all.

Ergonomics

- Most second stages are made of polycarbonate and are near neutral in water
- Exhaust tees are helpful in reducing bubble interference
- Some hose routing designs can cause 2nd stage to sit awkwardly in your mouth
- Mouthpiece design is an important comfort factor
- Custom mouthpieces are a nice feature but can cause problems when donating primary reg

Try before you buy – ergonomics are very personal. A good relationship with your LDS will comes in handy.

Special Considerations – Cold Water

- Regulators can start to freeze in 50F fresh water
  - Regulators will typically fail open but free-flow can block gas flow in the 2nd stage
- Diaphragm first stages are much less susceptible to freezing
  - Environmental sealing for pistons is complicated
- CW 2nd stages will feature a radiator to prevent freezing at valve orifice
- Brass 2nd stage parts can help prevent freezing but are not a common feature

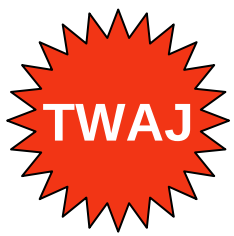
A regulator that is designed for cold water is a wise investment for New England divers.

Special Considerations - Nitrox

- Regulators that will be used with >40% oxygen need to be O2 compatible
  - Special o-rings and grease – Viton, etc.
  - Special cleaning to remove hydrocarbons throughout the reg
  - All pieces must be O2 clean including SPG
- A common use for O2 clean regulators is for stage/deco bottles
  - Low-performance regulators will provide adequate gas delivery and are much less likely to free-flow
  - DIN fittings are *de rigeur* for stage regs and bottles

Selecting a Regulator – My Advice

- Objective information on regulator performance is hard to find
  - Manufacturer claims should be scrutinized carefully
  - Most product reviews are not objective tests
    - Rodale's testing is probably the best available, but is still subject to manufacturer manipulation and advertising pressure
- If possible, try before you buy
- Keep in mind – the first stage does all the work
- <u>The most important feature of your new regulator is the person who services it</u>
  - Do not buy life support equipment over the Internet
  - Make sure that you know and trust the person who will handle your regulator



Care and Feeding

- Many problems can be prevented with proper care and feeding
- Regular maintenance by a qualified technician is important
- A small investment in tools can pay high dividends
  - Minimum:
    - Scuba Tool
    - O-rings and silicone grease (for non-O2 clean regs)
    - Spare port plugs
  - Worth investing in:
    - 9/16” open end wrench
    - Dedicated hex keys
    - IP gauge
    - Air blaster

Before Every Dive

- Turn your gas on SLOWLY and completely
- Listen for leaks on the surface and do a bubble check with your buddy @ 15ft
  - Bubbling from hoses is a sign of pending failure
- Check diaphragm cover and 2nd stage attachment
  - Both can easily work loose in the cold
- Set 2nd stage adjustments before dive

After Every Dive

- Dry dust cover before replacing
  - Do not blow air (and water) into regulator
- Soak if possible but at least rinse thoroughly
  - Best to do this while attached to a tank and pressurized
    - Do not press purge valve if not pressurized
    - Do not immerse in water for long periods of time if not pressurized
  - Pull back hose strain relief from fitting
  - Blow dry if possible

At Home

- Putting Your Reg to Bed
  - Rinse/Soak thoroughly
  - Back off cracking pressure adjustment
  - Coil loosely in a clean dry place
    - A Rubbermaid tub makes an excellent home
- Waking it Up
  - Visually inspect for dings and nicks – particularly in the hoses
  - Periodically inspect the o-rings on your hose ends and plugs