<u>Diving Regulators – All you needed to know…….</u>

Of all the SCUBA equipment that you will purchase, the regulator will be the most important item. You will want it to deliver life-sustaining air to you, easily and smoothly, without having to think about it. Selecting a regulator for purchase can be a rather daunting task especially if you are a new diver. Of course, your instructor and club divers will be able to offer you advice and the following article will hopefully demystify some of the terminology to help you make the right choice.

Purpose:

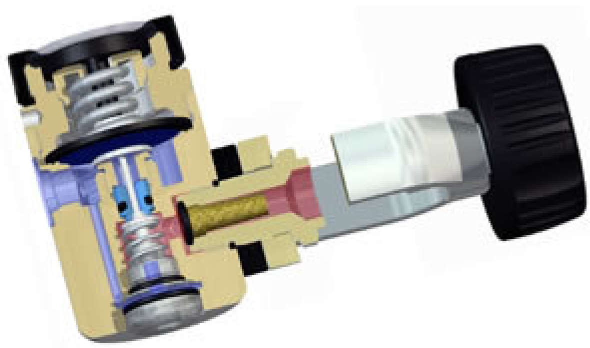
- The purpose of a regulator is to take high-pressure air from the cylinder and deliver it to the diver at a pressure equal to your surrounding depth (ambient pressure). This is because the human lungs can only take in air that is delivered at ambient pressure. To accomplish this, the air must go through two pressure reduction valves - the first stage and the second stage. The first stage attaches to the cylinder valve and takes incoming high-pressure air from the cylinder and reduces it to an inter-stage pressure of approximately 8-10 bar above ambient. The second stage (or demand valve), delivers air to the diver at ambient pressure, on demand.

Components:

The components of a regulator are :

A First Stage
A High Pressure Hose
A Contents Gauge
One or More Low Pressure Hoses (or Feeds)
One or more Second stages (or Demand Valves)

First Stage



(First stage schematic courtesy of Zeagle Systems)

- A first stage is a pressure reducing valve which reduces high pressure gases from a cylinder to a lower, inter-stage (hose) pressure.
- The inter-stage pressure is usually set at the factory to between 8 to 10 bar above ambient water pressure, depending on regulator type.
- A first stage may be manufactured from Chrome-plated Brass, Stainless Steel or Aluminium Alloy. Stainless Steel is much harder and resistant to damage. Some Brass first stages are now Titanium coated and have Titanium parts. Titanium is very hard and corrosion resistant, but is very expensive! Also be warned that some Titanium regulators cannot be used with Nitrox!
- Many regulators can be oxygen-cleaned for use with Nitrox, and most new regulators are able to be used with Nitrox, up to 40%, straight from the box.
- Oxygen-dedicated regulators are available and these are O2-cleaned at the factory and come equipped with O2-compatible O-rings and lubricants. They are colour-coded, normally in yellow and green, although some manufacturers use blue as their colour for Nitrox.
- If an O2-clean regulator is used with an ordinary compressed air supply, it immediately loses its O2-clean status and will require expensive re-cleaning before it can be used for O2 again.
- Environment sealing of the first stage encloses all working parts from the environment – environmentally sealed first stages may be used in any environment without affect. However, environmental sealing MAY affect the performance of the regulator. Environmentally sealed regulators are normally cold-water certified.
- Anti-freezing kits may be fitted to prevent ice particles forming within the 1st stage mechanisms which would cause a free-flow of the cylinder contents. Some anti-freeze kits provide an insulated layer of silicon or alcohol base fluid between the external water and piston or diaphragm. Whilst pressure is transmitted through the medium it acts to as an insulator to cold water, reducing the risk of freezing up the first stage.
- Some recent regulators use a 'Dry-Chamber' to separate the external water from the piston or diaphragm to reduce freezing.
- Regulators sold in European countries must conform to the European CE standards. This is a sign that the regulator has been manufactured and tested to ensure that it is safe in operation for its intended use. The 'standard' used for CE marking is British Standard BS EN250:2000
- First stages are attached to the cylinder (pillar) valve either by an 'A'-clamp fitting (also called an International fitting) – 232 bar max – or a DIN fitting which may be rated to 232 or 300 bar dependant on the length of the valve thread.
- DIN fittings are more robust and reliable than A-clamp fittings. Ensure that the fitting chosen matches that of the cylinder valve to which it is to be attached!

- The first stage will have at least one high pressure (HP) port (threaded opening) to enable a cylinder contents gauge to be connected.
- Some 1st stages have a second HP port which allows for optimal configuration and also the mounting of a wireless transmitter which relays the cylinder pressure to a wrist mounted computer.
- The first stage will usually have at least 3 inter-stage pressure ports which allows gas to feed the 2nd Stage breathing regulator (Demand Valve), Dry-suit/Buoyancy Compensator and secondary 2nd Stage Octopus Regulator.
- Some first stages have a specific port for the connection of the Demand Valve – these ports may have a different diameter (usually larger for a more efficient gas flow) to the 'standard' inter-stage ports.
- High pressure ports are normally a larger diameter than inter-stage pressure ports.
- When not in use, ports are 'capped' by blanking plugs, which are inserted and removed using an Allen key.
- Some first stages have a 'Turret' design with two fixed high pressure ports with four inter-stage pressure ports on a swivel fitting – this allows for a more convenient route for the hoses.
- Check that the configuration of the ports suits your preferred equipment configuration prior to buying a regulator.
- A first stage will have a Sintered bronze filter fitted at the cylinder interface. The filter prevents, potentially damaging, foreign particles from entering the first stage. The filters are usually flat but some are conical. After use a filter may show a different colour indicating likely contaminates:

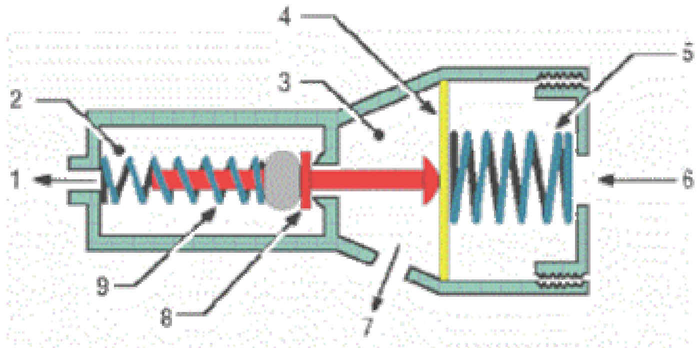
    - Reddish brown - Rust from a steel cylinder
    - Black - Carbon from compressor filter breaking down OR Oil from a faulty compressor
    - Turquoise, green or white - Salt water ingress
    - Paint like flakes - Certain cylinders are lined and this means that the lining is breaking down

- There are four types of First Stage valve:

    - Unbalanced Diaphragm
    - Unbalanced Piston
    - Balanced Diaphragm
    - Balanced Piston

- With unbalanced valves, the falling cylinder pressure will cause the inter-stage pressure to change during the dive – a balanced valve is unaffected by cylinder pressure.
- Unbalanced valves are also forced to have a smaller orifice to reduce the opening and closing effect of the high pressure air. A small orifice acts as a restriction and decreases the performance of the regulator at depth. With a balanced valve, high pressure air plays no part on the opening or closing of the valve, and they can therefore use wider orifices and can also cope with higher pressure air.

- **Unbalanced Diaphragm Valve**



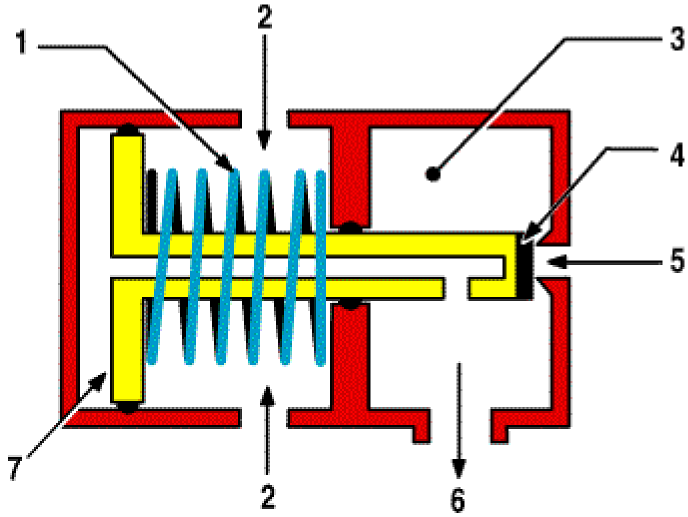
1. HP air
2. HP air chamber
3. Inter-stage chamber
4. Diaphragm
5. Diaphragm balance spring
6. Ambient water pressure
7. Air to second stage
8. Poppet valve & HP seat assembly
9. Poppet valve balance spring

- The original design of regulator
- Rarely (if ever!) used these days
- Also known as an upstream first stage as the seat is on the high pressure side of the valve
- Water and inter-stage chamber are separated by a thick flexible rubber diaphragm.
- On diaphragm model first stages, the water pressure acts on the main diaphragm, and this transfers the pressure to the inner valve of the unit
- Inhalation causes air to flow out of the inter-stage chamber, causing the inter-stage chamber pressure to fall. Lower inter-stage chamber pressure causes the diaphragm to flex inward, which pushes a rod, connected to a poppet valve, inwards. This allows high pressure air into the inter-stage chamber. When inhalation ceases, the increase in pressure in the inter-stage chamber, straightens the diaphragm and allows the lightly sprung poppet valve to close.

- Advantages of an Unbalanced Diaphragm valve are :
  - The moving parts are protected
  - They are easily adjusted and serviced
  - They are reliable

- Disadvantages of an Unbalance Diaphragm valve are:
  - As the valve is directly affected by the high pressure air, the inter-stage pressure will vary dependant on cylinder pressure.

- **Unbalanced Piston Valve**



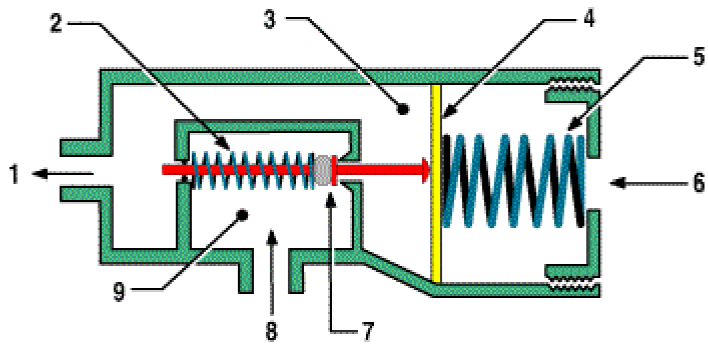
1. HP spring
2. Ambient water pressure
3. Inter-stage chamber
4. Valve and HP seat assembly
5. HP air
6. Air to second stage
7. First stage unbalance piston

- Introduced in the 1950's and still in use today.
- It works through the forces exerted on a hollow 'T' shaped piston – low pressure on a large surface (the 'top' of the 'T') can exert a force greater than a high pressure on a small surface (the bottom of the 'T')
- The piston moves back and forth within a smooth cylinder. An 'O'-ring acts as a seal around the piston stem.
- When a diver inhales, the inter-stage pressure drops which causes the piston to move in. High pressure air now flows into the inter-stage chamber (and thence the hose), until the diver stops breathing. Inter-stage pressure then builds and, acting on the large surface area on the top of the 'T', closes the valve.

- Advantages of an unbalanced Piston valve are :
  - They are easy to manufacture
  - Little can malfunction making them ideal for dive schools or remote diving operations.

- Disadvantages of an unbalanced Piston valve are :
  - Moving parts are in contact with water and sediments
  - Adjustments are complicated with shims
  - Valves cannot handle high pressures
  - Inter-stage hose pressure varies

- **Balanced Diaphragm Valve**



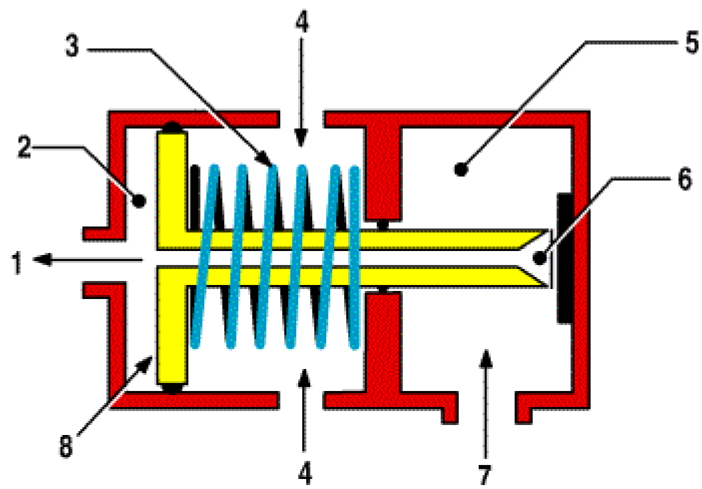
1. Air to second stage
2. Poppet Valve balance spring
3. Inter-stage chamber
4. Diaphragm
5. Balance spring
6. Ambient water pressure
7. Poppet valve & HP seat assembly
8. HP air
9. HP air chamber

- Similar in design and operation to the unbalanced diaphragm but with the addition of a small balancing chamber
- The balancing chamber is a small inter-stage pressure chamber that fits over the hollow stem of the poppet valve.
- Inter-stage pressure air enters the balance chamber through the hollow poppet stem. This balances the pressure on both sides of the valve and makes the valve easier to open.

- Advantages of a Balanced Diaphragm valve are:
  - They are easily adjusted and serviced
  - They are reliable
  - The moving parts are protected
  - The valve can handle high pressures
  - They maintain a very stable inter-stage hose pressure, irrespective of cylinder pressure.
  - Little force is required to operate the valve.

- Disadvantages of a Balanced Diaphragm valve are:
  - They are extremely complicated to manufacture and are therefore expensive to buy
  - They have many moving parts and require regular servicing by competent technicians

- **Balanced Piston Valve**



1. Air to second stage
2. Inter-stage chamber
3. HP spring
4. Ambient water pressure
5. HP air chamber
6. Valve and HP seat assembly
7. HP air
8. Balanced piston assembly

- The most widely used first stage.
- Often called a Knife Edge Piston valve as the piston has a sharply machined edge. The sharp edge seals against a Teflon seat pressed into the end of the high pressure chamber.
- High pressure air surrounds the stem but is not in contact with an end, therefore the valve is unaffected by the high pressure air

- Advantages of a Balanced Piston valve are:
  - It is a very simple design and is very easy to manufacture.
  - These valves can handle high pressures.
  - They give a constant inter-stage pressure, irrespective of cylinder contents.
  - Little force is required to operate the valve.

- Disadvantages of a Balanced Piston valve are:
  - Moving parts are in contact with water and sediment
  - The Teflon seat may wear causing changed inter-stage pressures
  - The knife edge is also very susceptible to damage
  - They are complicated to adjust.
  - Two vital O ring seals inside the first stage are subject to malfunction if damaged by sand or salt crystals.

Second Stage

(Second Stage schematic courtesy of Zeagle Systems)

- Also known as a Demand Valve as it delivers gas on demand
- It reduces gas at inter-stage pressure to ambient water pressure to enable to a diver to breathe normally.
- There are two main styles:
    - The conventional second stage has the diaphragm and purge button at the front, with an exhaust at the bottom. Most of these cannot be used upside down as water may leak into the diver's air if used whilst inverted. These are the most popular types and are familiar to most divers. They are easy to clear and also to strip and repair.

    - The second type has the purge button and the exhaust manifold on the side and these can be used either way. They are often more compact but they need to have the exhaust side lower in order to clear and this has caused several incidents when buddy breathing. They can be used right or left sides, but bubbles often interfere with a divers vision.

- Demand Valves may be manufactured from ABS plastics, Brass, Aluminium, Stainless Steel or even Carbon Fibre.
- Demand Valves incorporate an exhaust manifold to enable expired air to be vented, it is conventionally under the mouthpiece and angled to direct expelled air away from the divers field of vision.
- Demand Valves also incorporate a purge button to enable air to be injected into the valve to aid the purging of water from the valve, testing the valve pre-dive, or to vent the inter-stage pressure for disassembly.
- Demand Valves with metal casings offer more resilience to freezing in cold water due to better heat transfer between the water and the colder air.
- Some Demand Valves are equipped with metal heat exchangers on the connecting inter-stage hose – these again help transfer some heat between the water and the cooler air.
- Demand Valves may be fitted with an adjustable venturi lever which adjusts the effects of air pressure on the diaphragm and prevents regulators from free-flowing when on the surface.
- Demand Valves are affected by a Venturi effect. The rush of air within the body of the second stage causes a suction effect which allows the pressure-sensitive diaphragm to be pulled in and the valve lever to be depressed. This is prevalent at the surface at the start of a dive.
- Many second stage designs have an adjustable flap of material within them to redirect the flow of air back onto the inner side of the diaphragm, thus countering the effect. This flap is moved out of the air-flow by the diver once submerged – the movement of this flap is by a Venturi +/- switch (a.k.a. Pre-Dive switch)
- Mares regulators control the Venturi effect by incorporating a by-pass tube (VAD) which takes air directly from the second-stage valve to the mouthpiece. This avoids the main body of the second stage and neatly side-steps the problem.
- Demand Valves may be fitted with a Breathing Resistance Adjustment (BRA) mechanism to adjust the amount of breathing effort required to draw air.
- Choose a method of colour/touch to identify different 2nd stages and respective gas mixes.

- There are three different types of Second Stage valves:
    - Upstream Valve
    - Downstream Valve
    - Pilot Valve

- **Upstream Valves**

  - A very simple method of controlling the flow of air
  - Also known as a Tilt Valve
  - Primarily used on the original SCUBA Demand Valves, they are rarely found today.
  - Activation is by a lever in contact with a diaphragm exposed, on one side, to water.
  - If depth increases, or the diver inhales, the diaphragm distorts inwards and pushes the lever.
  - The lever tilts the upstream valve off its seat and allows air to flow from the attached inter-stage pressure hose.
  - A mushroom exhaust valve opens during exhalation, allowing expired air out, but not letting water in.
  - In the event of a first stage failure, high pressure air may come down the hose. In this instance the valve will close tightly and cause the hose to rupture. To prevent this, the valve must be equipped with a pressure relief valve.

  - Disadvantages of these valves are:
    - To minimise the closing force, the orifice supplying air into the valve must be kept small – this reduces air flow
    - Air flow is further reduced as the opening rod passes through the orifice.
    - The valves tend to wear unevenly increasing the chance for leaks
    - They require a pressure relief valve in case of first stage failure

  - Advantages of these valves are:
    - They are simple and cheap to make
    - They require no adjustment or tuning
    - They can handle varied inter-stage pressure

- **Downstream Valves**

  - The most common used valve today
  - Similar in operation to an upstream valve. When the diver inhales, the diaphragm is displaced which acts on a lever. The action on the lever lifts a small rubber poppet off its seat which allows the air to flow.
  - When the inhalation is ceased, the diaphragm straightens and the poppet is re-seated by a small spring
  - Being downstream the valve opens with the flow of air which allows the inter-stage pressure air to assist in opening the valve.
  - The amount of force required to open the valve can be precisely adjusted, using as adjustable seat, or by adjusting the lever height or spring tension.
  - In the event of a first stage failure, a downstream valve simply free flows.

  - Disadvantages of these valves are:
    - More difficult to design
    - More expensive to manufacture
    - Only operate in a tight range of pressure
    - Require more care & maintenance

  - Advantages of these valves are:
    - A large orifice can be used for a better air flow
    - The spring pressure is adjustable, allowing fine tuning
    - In the event of a first stage failure, the valve will free-flow

- **Pilot Valves**

  - Not in wide use (The Oceanic Zeta is an example)
  - They are based on the demand valve lever opening a small valve as a result of breathing action on the diaphragm
  - Opening the valve causes a drop in the chamber pressure which allows the inter-stage pressure air in the hose to open the main valve
  - On completion of the inhalation, the pilot valve closes and the pressure in the chamber builds up and closes the main valve.
  - The main valve is usually a small rubber pad about 2cm in diameter.

  - Disadvantages of these valves are:
    - They have a noticeable delay on inhalation and shut-off
    - They are complex and temperamental

  - Advantages of these valves are:
    - They have a high air volume delivery with less effort
    - They allow different configurations which results in the second stage having various shapes and sizes.

Contents Gauge

- Normally made of Brass with a mineral glass face. A plastic face may be used, but these can warp at greater depths (>60m) and give a false reading.
- Normally attached to the cylinder via a high pressure hose which is connected to the high pressure port on the regulator first stage.
- May be part of a wrist mounted computer which receives cylinder contents information via a wireless radio transmitter attached to the high pressure port on the regulator 1st stage.
- The normal analogue gauge can be held in the palm of a hand, but most are usually fixed in a console, a plastic or rubber box, that holds the contents gauge and probably a depth gauge and a compass. Whilst convenient, consoles can be bulky and heavy.
- Contents gauges can normally swivel on the hose. The ability to swivel requires the presence of a swivel pin which uses two small ‘O’-rings. As sand and salt particles can quickly wear the ‘O’-rings it is normal to have the swivel pin replaced when a regulator is serviced. It is also useful to have a spare one in your spares kit.
- A Button gauge is a small coin-sized analogue contents gauge fitted directly to the first stage high pressure port. Button gauges allow a diver to check the cylinder contents before a dive, but, unless used on a side mounted decompression cylinder, cannot be checked by the diver during a dive. They are also difficult to read accurately.
- Contents gauges are available in both BAR and PSI measurements – for UK diving (and most non-American influenced countries!) BAR measurements are normal. (N.B. 1 Bar = 14.5 PSI approx.)
- The low pressure zone should be highlighted and the gauge be easily readable.
- Contents gauges are actually Simplex Bourdon-Tube Gauges and operate via a C-shaped Bourdon Tube. They operate on the principle that pressure in a sealed curved tube has a tendency to straighten out the tube. This curved tube is made of steel and the free-end of the sealed tube drives the gauge needle via a geared linkage.
- Should the tube leak, the pressure will break the gauge glass. Any failure is likely to occur when first pressurising the gauge, so the gauge glass should be held against a firm (non-puncturable!) surface to ensure that any glass fragments are not hazardous.

Regulator Maintenance

- Regulators must be serviced by qualified technicians
- Regulators should be serviced annually or bi-annually depending on the number of dives undertaken, the type of dives and the conditions which are dived in.
- Servicing will typically cost between £50 - £80 per regulator (1^{st} & 2^{nd} stages) not including parts.
- When cleaning, always leave the regulators attached to the cylinder and pressurised. This will prevent water from entering the hoses and ultimately the first stage mechanism.
- After a diving day, rinse the 1^{st} and 2^{nd} stages thoroughly with fresh water.
- At home, following a sea dive, soak the 2^{nd} stage in warm (25-40 degrees C), mild soapy water for fifteen minutes or longer, prior to rinsing with fresh water.
- Do not soak the first stage, even if the dust cap is fitted – water may seep in!
- Remove moisture from the dust cap before refitting – there is no need to use a shriek of high pressure air from your cylinder to clear water away. A good blow or a wipe with a clean absorbent cloth is all that is needed!
- If water enters the first stage, have it professionally serviced as water in a first stage may cause it to suddenly fail.
- Allow the regulator to dry completely before storing in a clean, cool and dry place.
- Avoid leaving the regulator in direct sunlight.
- Do NOT carry a SCUBA set by the regulator or Hose
- Check for salt and sand build-up around the contents gauge hose swivel connection, particularly if it is housed in a console or is protected by a boot.
- Avoid dropping the regulator or placing it in sand.
- Inspect High and Low pressure hoses regularly for signs of wear or damage. Replace them if any damage or wear is found.
- Fit hose protectors at attachment points to the first stage to reduce the amount of bending and stress at these points
- If fitted, slide hose protectors along the hose to enable cleaning and inspection.
- Check Demand Valve mouthpieces are secure and are not cut/cracked – replace if necessary.

Troubleshooting

N.B. All technical maintenance work **MUST** be undertaken by a suitably qualified service technician. **DO NOT** attempt to undertake technical repairs unless you are qualified to do so – your life may depend on this!

Problem	Probable Cause	Solution
Free-Flow	▪ First stage seat ▪ Second stage seat ▪ Incorrect inter-stage pressure ▪ Corrosion ▪ Dirt	▪ Check & Replace ▪ Check & Replace ▪ Re-adjust ▪ Clean ▪ Clean
HP Leak	▪ 'O'-ring ▪ 'O'-rings on hose swivel	▪ Replace ▪ Replace
LP Leak	▪ 'O'-rings	▪ Replace
Hard Inhalation	▪ Low inter-stage pressure ▪ Corrosion or dirt	▪ Re-adjust ▪ Clean
Hard Exhalation	▪ Perished exhaust port ▪ Blocked exhaust T	▪ Replace ▪ Clear
Water entering the 2nd stage	▪ Split mouthpiece ▪ Damaged diaphragm ▪ Damaged or kinked exhaust port ▪ Cracked housing	▪ Replace ▪ Replace ▪ Replace or adjust ▪ Replace
Weak Purge	▪ Low inter-stage pressure ▪ Incorrect adjustment	▪ Re-adjust ▪ Re-adjust
Erratic air flow	▪ First stage seat ▪ Incorrect inter-stage pressure ▪ 2nd stage corrosion	▪ Replace ▪ Re-adjust ▪ Clean
Air leaks from 1st stage	▪ Damaged 'O'-rings ▪ Diaphragm not sealing	▪ Replace ▪ Check
Regular blowing off from the 2nd stage	▪ Incorrect inter-stage pressure ▪ 1st stage valve failure – it blows off the 2nd stage valve before building pressure again	▪ Check & adjust ▪ Replace valve

Useful spares to have:

- 'O'-rings – Standard Valve, High Pressure, Low Pressure and Swivel Pin (ensure that you have Viton ones if using Nitrox >40%)
- High Pressure Swivel Pin
- Mouthpiece
- High and Low Pressure port blanks
- Cable ties

Useful tools to have:

- Allen Keys (4, 5 & 8 mm)
- Spanners (5/8, 9/16, 13mm, Adjustable)
- Screw drivers (Small set)

Regulator Glossary

Item	Description
1^{st} Stage	Pressure reducing valve which is directly attached to the cylinder pillar valve by either an A-Clamp or DIN fitting
2^{nd} Stage	Pressure reducing valve which enables the gas at inter-stage pressure to be reduced to ambient pressure in order that it may be breathed.
A-Clamp	a.k.a. International – standard 'horse-collar' design for attaching the regulator to the cylinder valve.
Ambient Pressure	The actual pressure exerted by the atmosphere plus depth of water.
Anti-Freeze Kit	Normally a special 1^{st} stage modification kit to resist the build up of ice particles during cold water dives. The kit provides an insulated layer of silicon or alcohol base fluid between the external water and piston or diaphragm. Whilst pressure is transmitted through the medium it acts to as an insulator to cold water, reducing the risk of freezing up the first stage See also Environmental Protection and Dry-Chamber.
ANSTI	An independent UK company who specialise in the design, manufacturing and supply of systems for testing respiratory equipment. ANSTI systems are used by most of the SCUBA regulator manufacturers worldwide, to ensure that their products meet current EU and US standards.
Balanced Valve	Both piston and diaphragm first stages may be balanced. This means that as the air in the cylinder is depleted during the course of the dive, the intermediate pressure going through the hose remains constant. This results in consistent, easy breathing from the beginning of your dive until the end.
Bourdon Tube	'C' shaped brass tube which is used within a contents gauge to measure the cylinder pressure.
Breathing Resistance Adjustment (BRA)	A splined knob that changes spring pressure on the opening valve. By adjusting the knob the diver can adjust the cracking pressure. This may be useful in heavy surf to avoid a free flow on entry or diving in a current. The down side is a more complicated unit and reduced performance. The advantages are minimal unless you want to fit a regulator to a full-face mask or underwater communications device.
CE Mark	Indicates that the regulator meets the breathing requirements laid down in European Union law. The 'standard' used for CE marking is British Standard BS EN250:2000. These tests are undertaken using ANSTI machines.
Chamber	An air space within a 1^{st} stage.
Cracking Pressure	This is the amount of inhalation force needed to open the valve and start the air flow. This should be as low as possible. As the hose pressure on a good regulator is constant this can be set exactly. It is adjusted and set by the factory or by a technician.
Demand Valve	a.k.a. 2^{nd} stage. A Demand Valve does exactly what it says on the box – it delivers air (or gas) when demanded!

DIN	DIN – Deutsches Institut fur Normung – A German manufacturing standard. DIN fitting valves are available in either 232 or 300 bar versions. 232 bar versions have a shorter thread so will not fit 300 bar cylinder valves. 300 bar versions can fit either 232 bar or 300 bar cylinder valves. An ‘O’-ring is fitted to the regulator thread, not the cylinder valve and is therefore internal and protected when in use. DIN valves are more compact and robust and they are less prone to ‘O’-ring failure. They are used more in ‘Technical’ diving. Prevalent in Germany and some European countries. Also prevalent worldwide where German tourism is high (i.e. Maldives, Mediterranean, some Red Sea resorts)
Diaphragm	A diaphragm is a flexible seal which enables the ambient water pressure to be regulate the inter-stage pressure. A diaphragm also keeps water away from the working parts of the regulator first stage and so are the best choice for use in dirty or cold water.
Downstream Valves	Most regulators manufactured today incorporate the use of downstream valves in second stages. This means that the valve seat is situated in the down-stream or after-side of the valve assembly and opens with the flow of air rather than against it. This is an important design feature since it allows the intermediate air pressure to assist in opening the valve. Thus if the first stage valve should malfunction the high pressure air would not damage the hose or the second stage. Instead it would force the open the second stage valve and cause the regulator to free flow while still providing air to the diver.
Dry-Chamber	An alternate method of Anti-Freezing a regulator. Instead of filling the first stage with Silicon fluid or alcohol, the chamber between the water and the diaphragm or piston is kept completely dry to prevent moisture from freezing.
Elbow	A stainless-steel flexible joint on a low-pressure hose. Allows for better hose routings and comfort.
Environmental Protection	All diaphragm 1st stages are environmentally protected by design. Piston valve 1st stages can have an optional kit fitted which prevents water from entering the valve thereby protecting it from contaminants. As environmental protection also prevents water from entering the valve, it increases the cold-water performance of a valve
Exhaust Tee	Allows for the escape of exhaled gas from the second stage. Usually found at the base of a conventional regulator, but may be at the side.
Free-Flow	Free flow is the unrestricted venting of the cylinder contents. Free Flows occur when either the first stage valve freezes open or when a finely set, high-performance second stage regulator is at the cusp of the water and the air. In these instances the pressure on the second stage diaphragm causes it to open and for the air to free-flow. See Pre-Dive switch and Venturi Adjustment.

Heat Exchangers/Sinks	Heat Exchangers, or Heat sinks, are metal parts, which conduct heat from the water to the much colder air. The already cool cylinder air, is liable to cool further as its pressure is reduced within the 1st stage. This can cause water within the 1st stage to freeze and interfere with its operation, with potentially disastrous consequences. Heat sinks reduce the potential 1st stage freezing by conducting heat from the water to the air. Some 2nd stages are made from metal, again in an attempt to transfer heat from the water to the air. Metal vanes on the end of 2nd stage inter-stage hoses also act in the same way.
Hose	Hoses connect the regulator first stage to the second stage(s), contents gauge and B.C./Drysuit. They are made of rubber coated reinforced braided plastic.
Inhalation Pressure	See Cracking Pressure
Inter-stage (or Intermediate) Pressure	The Inter-Stage pressure is the pressure which is maintained between the first and second stages of the regulator. This pressure is normally set to between 8 and 10 bar above the ambient pressure. Inter-stage pressure gas is used to supply direct feeds to a divers B.C. or Dry-suit without further reduction.
Mouthpiece	A Silicon, Rubber or Plastic replaceable moulded unit which attaches (usually with a simple cable tie) to the regulator second stage. It allows the diver to comfortably hold the second stage in their mouth, usually by biting on moulded lugs. Various styles and sizes are available and some can be specifically made to cater for a users 'bite'.
Nitrox	A gas in which the standard Nitrogen content (79%) has been reduced and replaced with pure Oxygen. Most new regulators can be used with Nitrox up to 40%, but the purchaser should check this before buying if Nitrox is going to be used. For Nitrox above 40%, regulators must be O2 clean and in O2 service.
'O'-ring	A sealing ring used in various parts of the regulator. Usually made of Rubber for air use or Viton (or some other non-hydrocarbon based compound) for Nitrox use. Internal 'O'-rings will be replaced during a regulator service. 'O' rings at the interface between the first stage and the cylinder valve may perish and it is useful to have spare 'O'-rings of the correct size and type in your dive kit.
O2 Clean	Equipment has been cleaned for use with pure Oxygen
O2 Compatible	The equipment has been specifically made in an O2 clean environment and uses materials which are suitable for use in high O2 areas. These regulators atSuitable for use with pure Oxygen
O2 Service	O2 Clean and O2 Compatible = O2 Service
Octopus	A second 2nd stage for use in an out-of-air situation. An octopus regulator should be matched to the performance of the 1st stage. Octopus regulators are normally coloured yellow of have a yellow hose to be more obvious to the out-of-air diver.

Over-Balanced Valve	An innovation only found in the highest performing regulators is called over-balancing. The diaphragm that provides the environmental seal is larger than the internal diaphragm. This means that as you get deeper more pressure is applied to the external diaphragm than would be applied to the smaller internal diaphragm due to the increased surface area. This actually boosts pressure at greater depths significantly improving performance. '
Pilot Valve	Pilot Valves are a type of valve used in some second stages. They are based on the demand valve lever opening a small valve as a result of breathing action on the diaphragm. Opening the valve causes a drop in the chamber pressure which allows the inter-stage pressure air in the hose to open the main valve. On completion of the inhalation, the pilot valve closes and the pressure in the chamber builds up and closes the main valve.
Piston	In piston regulators, external water pressure acts directly on a piston which is the main moving part. Piston regulators often sacrifice performance for simplicity. This means they are a better choice for those going to remote locations and who might need to do their own servicing. Scubapro regulators are favourites in such places, as are the piston-type designs from Oceanic.
Port	A 1st stage outlet for gas. Ports are threaded outlets which allow the diver to attach hoses, both high pressure and inter-stage pressure. Ports may have differing diameters and threads depending on the outlet gas pressure and use. Most regulators have at least 1 high-pressure port and 3 inter-stage pressure ports.
Pre-Dive switch	See Venturi Adjustment.
Purge Button	Located on the 2nd stage normally in the centre of the 2nd stage cover. Enables the diver to depress the 2nd stage valve lever to enable a blast of air to enter the valve and eject any water from the valve.
Shim	Not used on many regulators, shims are very thin washers which can be used to regulate the inter-stage pressure.
Silicon Fluid	A fluid used in anti-freezing kits.
SPG	Submersible Pressure Gauge – also known as a Cylinder Contents Gauge.
Swivel Pin	Small steel ‘pin’ which enables the contents gauge to swivel on the high pressure hose. The spigot also has two small ‘o’-ring which can perish and both the pin and the ‘o’-rings should be replaced when the valve is serviced.
Teflon	Teflon (yes, the same as in non-stick pans!), may be used to coat some internal regulator parts to prevent them from sticking when they become cold.

Unbalanced Valve	The performance of an unbalanced valve drops as the main cylinder pressure falls during the dive. They are cheaper to manufacture and this is revealed in the price. Unbalanced piston designs are more suitable for use by those who do undemanding dives, and for schools that want an inexpensive item for use by trainees in safe, confined water.
VAD	Vortex Assisted Design – A Mares patented design. Mares regulators incorporate a by-pass tube which takes air directly from the second-stage valve to the mouthpiece, avoiding the main body of the second stage and neatly side-stepping the venturi effect.
Valve	A **valve** is a mechanical device that regulates the flow of gases by opening, closing, or partially obstructing various passageways
Valve Seat	Rubber or Plastic surface that forms the valve seal
Venturi Adjustment	Several regulators have adjustable vanes, controlled by a Venturi +/- switch (or lever), that can increase or decrease the Venturi effect. These switches can also be called a Pre-Dive switch.
Venturi Effect	Moving air will pull still air with it, increasing the flow without further effort. Manufacturers use this principle in order to increase the performance of their regulators. Many have internal vanes to increase the venturi effect, several have adjustable vanes that can increase or decrease the free flow effect with a switch. Others have increased this effect by spiralling the air flow. Harnessing the venturi effect significantly increases the performance.
Viton	An inert compound which is used for 'O'-rings when gas with a high Oxygen content is used (usually > 40%)