EQUIPMENT

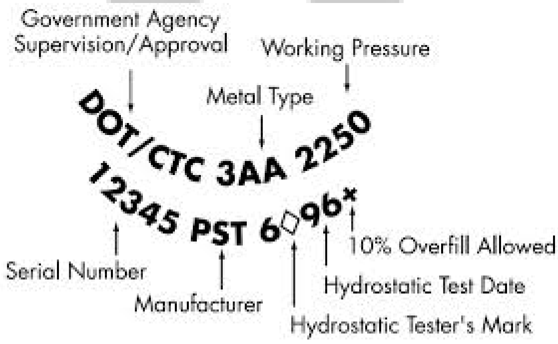
Scuba Cylinders:

All scuba cylinders have markings stamped at the neck. These will include, regardless of the country of manufacture, the following:

- Alloy designation (the metal type the cylinder is made from).
- Hydrostatic test date
- Working pressure
- Manufacturer’s name
- Serial number

Some cylinders will have other markings depending on the country of origin.

- Water capacity
- Test pressure
- + mark to indicate it can filled to10% more than its working pressure
- Volume of air held at the working pressure
- Distributor’s name
- Visual inspection stamp
- Batch number



Cylinders used for gases other than air should be clearly labeled as such. Some countries require certain colour codes on the paint work to indicate this.
In recreational and technical diving you will come across the following.

Enriched Air Nitrox cylinders colour coded clearly green and yellow, a label should indicate the percentage of oxygen in the mix. Up to 40% for recreational divers and up to 100% for technical divers. In the latter case they will probably be also labeled as deco mix.

Argon cylinders are used for dry suit inflation and should be clearly marked as such. These are never used to breathe from as you would die.

Cylinders used for trimix are usually marked with the oxygen content followed by the nitrogen content – the remaining content being helium.

All cylinders use for enriched air and technical diving should have a clearly labeled maximum operating depth (MOD). Or in the case of Trimix, Helitrox, Heliair or Heliox a minimum operating depth above which there is not enough oxygen to support life.

Breathing the wrong gas at the wrong depth results in **DEATH.**

All cylinders subject to partial pressure blending or used with more than 40% Oxygen should be oxygen clean, and the valves should be oxygen clean and oxygen compatible.

Failure to observe this rule can lead to fire and/or explosion leading to death or serious injury.

Virtually all scuba cylinders are made from steel or aluminium alloys.

Steel is stronger than aluminium, so steel tanks have thinner walls and larger internal volumes for a given external size.

Aluminium’s advantage is that it less subject to corrosion, you will find aluminium cylinders at most resorts in the tropics.

Steel cylinders are heavy in the water and therefore you need less lead on your belt. They also have rounded bottoms and need a rubber boot to stand up.

Cylinder testing:

Hydrostatic testing (pressure test) must be carried out periodically as required by the law of the country you are diving in.

The general procedure for the test is as follows:

- The cylinder is immersed in water and the volume of displaced water is measured.
- The cylinder is then filled with water and pressurized up to test pressure (This is stamped on the cylinder or it is 5/3 of the working pressure).
- The cylinder stretches slightly as this is done.
- Next the pressure is released and the tester again measures the displaced water to determine the cylinders new volume.
- The cylinder will have a small amount of permanent stretch if this is within limits set by the appropriate government the cylinder passes the test.
- Note that if the cylinder fails during the test it will not explode as it is filled with water that cannot expand.

Certain things will require that a cylinder be hydrostatically tested before the normal test period is up; these are:

- If the cylinder has been tumbled or sandblasted to remove corrosion.
- If the cylinder has suffered any damage due to impact.
- If the cylinder has been exposed to heat in excess of 82 degrees C.

- If the cylinder has been left unused for 2 years or more, especially with zero pressure.

A *__visual inspection__* of the scuba cylinder should be carried out at least annually. The exterior and interior of the cylinder is examined to see if a hydrostatic test is required. The valve is removed and serviced and the threads checked for any corrosion due to galvanic action.(More common an aluminum cylinders). The tank valve o ring is renewed and the burst disk in the tank valve is renewed.
This is a recommended industry standard but is required by law in the UK every two and a half years.

Tank Valves:

- K valve: This is a simple on off valve.
- J valve: This a valve with a reserve mechanism that cuts of the air at around 20-40 bar until the lever is operated. It does not give you extra air; only what you already had. Used extensively in diving before the advent of the SPG. When filling a tank with a J valve the lever should be in the down position.
- DIN valve: (Deutsche Industrie-Norm). The regulator screws into the tank valve giving some advantages over the yoke screw design.
    1. It gives a better seal between the tank and the regulator.
    2. The connection is stronger and is preferred by technical. Cave and wreck divers.
    3. It can take up to 300 bar pressure. (Yoke screw max.232 bar).

DIN valves can be J or K valves.

Y valves are tank valves which have two taps and two regulator points, either yoke screw or DIN. This enables two regulator first stages to be attached to a single tank.

Twin tanks have manifold valves, some with an isolator valve in the centre (recommended) so that tanks can be used independently in an emergency.

A burst disk is required by law in many countries and is installed into the tank valve to prevent dangerous over pressurisation. This is a thin copper disk that ruptures and allows the air to escape when the pressure reaches 125% to 166% of the working pressure of the cylinder. Burst disks are available with different burst pressures. They stretch over time and should be renewed annually when a visual inspection is carried out.

Another method of achieving this safety feature is a hole on the thread of the tank valve a couple of threads up, if the tank is over pressurised the air then leaks up through the thread and escapes from the top of the tank valve.

All tank valves have a plastic or metal anti-debris tube that extends from the bottom of the valve into the cylinder. If the cylinder has some debris from accumulated rust or a small amount of water is present this prevents this from traveling through the tank valve to the regulator.

Regulators:

First we will look at the three types of scuba (self contained underwater breathing apparatus) available to the diver and how each one works.

1. *<u>Open Circuit Scuba</u>*: This is probably the one you are more familiar with and is certainly the most commonly used and will be for the foreseeable future given the inherent simplicity and safety record of the unit. The diver inhales air from a cylinder via a demand valve regulator and exhales it into the water, thus the circuit is open because none of the air is recycled. This system is often referred to as "*open circuit demand*".
2. *<u>Semi-closed rebreather (SCR)</u>*: This has now crept into recreational diving and several courses are available. The diver inhales from a breathing bag that receives a steady flow of gas (usually enriched air nitrox). The diver exhales back into another bag and the gas has carbon dioxide removed chemically. Excess gas from the steady flow trickles out through a valve. The circuit is semi-closed because part of the gas is recycled and part of it is released.
3. *<u>Closed circuit rebreather (CCR)</u>*: This is still in the realm of the technical diver although becoming more popular with the sport diver as time goes on. The diver inhales from a breathing bag and exhales back into another one, the gas has carbon dioxide removed chemically, it is then analysed by oxygen sensors and a solenoid tops up the bag with oxygen as required. The diver adds dilutant air to the bag as he descends. Air is only released on ascent for buoyancy control. The partial pressure of the oxygen is monitored giving an ideal gas mix for whatever depth the diver may be. This greatly reduces any decompression penalties. Special unit-specific training is required.

Let's now look at how an open circuit regulator works…

The *first stage* reduces *high pressure air from the tank to an intermediate pressure* (usually around 10 bar above ambient).

When the diver inhales the intermediate pressure in the first stage drops below its normal level.

This allows the water pressure to flex a diaphragm or move a piston that releases air from the tank.

The air flows as long as the diver inhales keeping the first stage from reaching intermediate pressure.

When the diver stops inhaling the pressure rises back to intermediate pressure in the first stage and closes the valve from the tank.

The *second stage* reduces the *intermediate pressure to ambient pressure* for breathing.

When the diver inhales water pressure pushes in a diaphragm which opens the second stage downstream valve releasing air from the first stage.

As long as the diver inhales, air continues to flow.

When the diver stops inhaling the diaphragm returns to its relaxed position and the valve closes.

Exhaled air exits the second stage through one way exhaust valves.

On some second stage models, the diaphragm opens a small *pilot valve*, which creates a pressure imbalance which opens the main downstream valve.
This reduces breathing effort somewhat, but is a more complex design and is costly to service.

On some models there is a cracking resistance control which can be accessed by the diver. This adjusts the effort needed to open the second stage valve to a personal preference.

On many models you will find a venturi switch accessed by the diver. This deflects air to the diaphragm when in the off or minus position. This is to prevent the regulator from free flowing when getting in and out of the water. When it is set in the on or plus position it deflects air to the mouthpiece to reduce breathing effort. It should always be in this position once underwater. To test if this is adjusted OK. If you press the purge button out of the water when the lever is in the plus or on position the regulator should continue to free flow after you release the purge button. To stop this, switch the lever back to minus or block the mouthpiece with a finger.

To protect the high pressure seat from excessive wear on the first stage of a regulator. When you open the tank valve hold down a purge button or LPI on the BCD momentarily as you open the valve then release when the air starts to flow. This prevents the valve hitting the seat of the first stage with the full force of 200+ bar.

An *upstream valve* opens *against the flow of air* (like pushing a door open against a strong wind).
A *downstream valve* opens *with the air flow* (like pushing open a door with the wind behind you).

If there is a malfunction in the first stage, the intermediate pressure will rise and open the *downstream* valve, this will cause a continuous free flow of air rather than shutting off the air. It is known as a *failsafe* design.

Environmental seals are found on some regulator first stages. This is because normal air flow causes the temperature to drop as the gas is expanding, *in very cold water* this drop can cause water to freeze the regulator first stage valve in the open position resulting in a free flow of air. To avoid this some regulator first stages have environmental sealing. This seals silicon grease or a light oil around the first stage which is normally open to the water. The oil then transmits the water pressure to the diaphragm or piston so the regulator operates normally.

A newer way of solving this problem is with a dry sealed first stage this solves the problem without the complications associated with an oil-filled first stage.

Heat sinks on the second stage connection are another innovation to lessen this problem. Environmental sealing of this sort is also recommended for warmer water diving, to prevent salt corrosion inside the first stage and stop the possibility of sand or debris getting into the first stage.

An *unbalanced regulator* is one in which the tank air pressure either *resists or assists* the opening and closing of valves in the first stage.

This is cheaper to make, it becomes harder to breathe when there is less pressure in the tank. They are no longer commonly found.

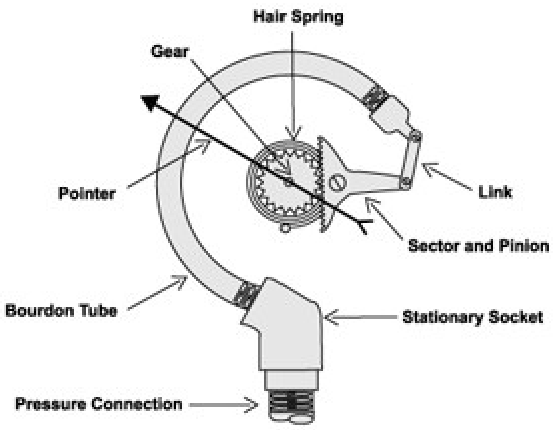
A *balanced regulator* is one in which the tank air pressure *neither resists nor assists* the opening and closings of valves in the first stage.

Breathing is easy at all tank pressures, better able to supply two divers and better for deeper diving. Nearly all modern regulators are of balanced design.

Depth gauges:

Capillary depth gauges are a simple piece of clear tubing, sealed at one end and open at the other, with depth increments indicated to where the water column rests according Boyle’s Law. The deeper you go the closer the depth increments become. They are inexpensive and reliable but are difficult to read when deeper than 10 metres. They are used for altitude diving as they will read theoretical depths instead of actual depths as they are based on Boyle’s Law, they are okay for snorkelers and for technical divers doing decompression stops as a back-up gauge as they are accurate in shallow water.

Open bourdon tube gauges contain a c-shaped shaped tube. Water enters the tubes open end and the increasing pressure causes the tube to straighten. This then moves the depth gauge needle. They are prone to clogging as the tube is open.



Oil-filled bourdon tube gauges use a sealed tube in an oil-filled housing, in this case the pressure transmitted by the oil to the tube causes it to tighten and move the depth gauge needle. These are better as they are not prone to clogging.

Diaphragm depth gauges function by connecting a flexible diaphragm to a series of levers and gears that move the display needle. These are more accurate than bourdon tubes but more expensive, they used to be the choice of the serious diver before the advent of dive computers.

Digital depth gauges are electronic gauges that read depth via a transducer, which varies the electrical current according to the pressure exerted on it. The greater the pressure the more current they produce. They provide a digital display. These offer the highest degree of accuracy and are used in dive computers and dive watches for determining depth.

Submersible Pressure Gauge (SPG):

The SPG works on the same principle as the bourdon tube gauge. High pressure air enters a c–shaped tube and causes it to straighten, causing the needle to move. These become less accurate over time usually giving a higher reading as the tube weakens. As long as the needle returns to zero you are safe.

Electronic SPGs use a pressure transducer similar to those in dive computers and are very accurate. These may be integrated into the computer which is attached to the high pressure hose or a hose-less radio version with the sender attached to HP port of the first stage and the display on the divers wrist.

Compasses:

The needle of the compass always points to magnetic north because the needle is a magnet. With most dive compasses the diver reads the heading directly against the needle. New electronic compasses give a digital reading, beware because they still have a traditional needle and swivel under the display so you still have to hold them level, you can tilt them a little bit more than a traditional compass but they can still get stuck.

All these compasses are oil-filled so the housing withstands the pressure, this also dampens the needle movement for easier reading.

Gauge Carrying options:

1. *Wrist mounted*: the diver straps the gauge to the wrist; useful for compact instruments. It is the most accurate placement for compass other than holding it. More streamlined than a console on the chest, especially in overhead environments. Can be more prone to entanglement.
2. Console: Combines several instruments into one package on the SPG or may integrate several instruments into one, such as a pressure integrated dive computer. This speeds up dive preparation, keeps arms clear for putting BCD and tank on and off. The console requires securing so it doesn't drag and damage the environment or itself.
3. Retractable mount: Gauge mount clips to BCD with a spring wound retraction cord. The diver pulls it out to read then it retracts out of the way. Good for hand holding a compass, good for hose-less computers for divers that don't like them on their wrist.

Enriched Air Equipment Considerations:

Apart from the oxygen cleaning and the general identification labels, each nitrox tank must have a visual inspection label stating it is oxygen clean for partial pressure blending or not oxygen clean and only suitable for continuous blending with mixes less than 40% oxygen. The cylinder must also have a contents sticker identifying the current blend, fill date, maximum operating depth and the analyser's/diver's name. *Each diver must personally analyse the gas in his own cylinder before using it.*