DIVING CYLINDERS

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(2021 edition)

Guestbook

(From the same author)

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INTRODUCTION

The knowledge acquired by the Visual Inspection Technicians (TIV) is not essential for all divers. However, they can provide valuable assistance in the selection, maintenance and use of dive cylinders. https://tiv.ffessm.fr/Account/Login

In France we usually speak of "Bottles" but also of blocks or "Bottles blocks". (According to the European standard) The Anglo-Saxons call them "Cylinders" or "Tanks", the Quebecers "Bonbonnes"...

In order to be useful to visitors preparing a diving level, we have introduced a TRAINING chapter at the end of which we propose some questions whose answers are found in the different other chapters.

Choose your bottle (See the characteristics in APPENDIX)

It is as much a matter of choosing a bottle from a lot for immediate use as of a choice for a purchase, or even a rental.

Before choosing a block (mono or bi), make sure that it can be attached to your buoy.

When choosing a bottle block, intervene:

The expected mixture

The new regulations in force since the November 2017 decree define the standards of use and the maintenance rules according to which the blocks must be used, in particular for mixtures over-oxygenated.

A special visual inspection procedure has been put in place by FFESSM. The Visual Inspection Technicians are authorised to carry out this inspection. This authorisation must be renewed every 5 years.

For older ITVs, there is no further training but they must follow the procedure set up and available on the federal website.

The volume

It will depend essentially on the user and its use.

The most used classic bottle has a volume of water of 12 liters. However, for children, a 6 litre bottle is preferred. On the other hand the supervisors will take a block of capacity higher than that of the members of their palanquin. (For example 15 liters, or 18 liters in mono or bi-bottles)

In the field of underground or technical diving, the volume of blocks is a strategy whose subject will not be discussed here, at least for the time being.

The operating pressure

It has gradually increased over the years. It went from 176 bars to 200 then 232 and finally today we can find blocks to 300 bars.

The interest is not as great as one might think because for a given stored volume the volume of the container does not decrease proportionally to the pressure, on the other hand its weight increases and its buoyancy decreases.

The dimensions

Today, for a given volume, we tend towards shorter cylinders compensated by an increase in diameter.

They are more resistant to pressure and can also be because they allow to sit while having them on their back. On the other hand, they have the disadvantage of being heavier both in the air and in the water.

The weight

The weight is related to the material, volume and shape. The table below gives the main cylinders used. Approximate dimensions are in millimetres.

The materials

In France, we mainly use steel. In the Anglo-Saxon countries, we use aluminum alloys a lot. Composite bottles begin to appear.

Steel:

It has the disadvantage of rapidly corroding especially in the presence of water. As a result of several accidents, very strict regulations have been put in place.

Aluminum:

Although it is not an absolute rule, with equal volume of water, aluminum is sometimes heavier in the air and lighter in the water. As a result, you have to add ballast to the water and carry it in the air with a heavier bottle.

The key difference with steel is that aluminum alloys are less susceptible to corrosion but more sensitive to cracks. (More difficult to detect) In theory, the regulations in France are the same regardless of the material used. Nevertheless, there is a reserve in the case of heavy use of aluminum. In this case, the pace of inspections must be increased.

Composites:

The bottles made of composite material are made according to various technologies. Their resistance to inflation stresses, temperature and time are not yet well known. Nevertheless, the same visual requalification and inspection constraints are imposed as for steel or even more for safety.

These bottles use resins that insulate them thermally from the outside. When they are inflated, they therefore heat more than steel or aluminum. This results in a greater loss of capacity which may require additional inflation after cooling.

Inflation

The diver wishes to have the cylinder inflated to the authorized operating pressure prior to diving. A number of factors thwart this wish.

I - The most important is the inflation speed. If it is high, when entering the cylinder, the air is compressed and heated. Under Amontons Law, his pressure increases.

The inflator stops inflation when the control manometer reaches operating pressure. Unfortunately, then the bottle cools and the pressure decreases.

A fairly common temperature rise of 30°C will result after cooling in a pressure loss of about 10%, which is not negligible.

This problem can be solved in 3 ways:

1. Allow the cylinder to cool and then proceed with additional inflation.
2. Use a low inflation rate. The heating speed is thus compensated by natural cooling. A calibrated nozzle placed before the connection system of each cylinder avoids exceeding the chosen speed.
3. Inflate the cylinder by immersing it in a water tank at room temperature. This latter practice is primarily of commercial interest. It ensures rapid inflation without loss of stored volume. (Except for composites)
4. Another advantage is that the bottles are rinsed well, provided the water is changed regularly. As for the safety it brings, it remains to be proven. (An explosion in the water is likely to throw ice in all directions)

II -The second factor is the wear of the station components and cylinder valves. Indeed, air molecules and particles that circulate at high speeds cause wear and tear of the parts they encounter. This is the case with seats and valves for high-pressure regulators, but also cylinder valves. In order to limit these degradations, the inflation rate must be reduced.

III - The third factor is the nature of the materials used.

- For steel: It is possible to inflate quickly, but to take account of other factors it is reasonable not to exceed 50 bar per minute or 600 litres per minute for a 12 litre bottle.

- For aluminum alloys: They are sensitive to rapid pressurization. (This promotes crack creation) It is recommended to stay between 15 and 35 bars per minutes.

- In the case of composites, it is mainly the fact that their resistance to pressure variations is still poorly known and that, as we have seen above, the resin coating does not favour their cooling. We will remember that it is better not to exceed 30 bars per minute.

Note:

It should be noted that with the use of buffers, the loading speed decreases with the decrease of the pressure reserve.

The autonomy sought

- It would be absurd to equip oneself with a bottle too heavy to increase its autonomy. Indeed, the heavier and bulkier the bottle, the higher the consumption. There is therefore a compromise to be found which may vary depending on the characteristics of the intended dive but also on the individual needs and training of the diver.

- It is interesting to know how to determine the autonomy of a given bottle.

Before the dive, we can estimate the autonomy by taking into account the pressure in the bottle, its volume and the depth that we propose to reach as well as a supposed consumption of 20 liters per minute. However, this is very approximate because the actual consumption of the diver and the variations in depth are not taken into account.

During the dive, range can be determined by the change in pressure over a given period of time. Provided you do not change the depth. (If the pressure decreases by 10 bar per minute and you have 120 bar in the bottle, you can say that the autonomy is 12 minutes)

To improve this estimate, it may be agreed to go back up when the 50 bar reserve pressure is reached. In the previous case, the autonomy is 7 minutes at the depth where we are. This still leaves a lot of room for errors due to depth variations or diver efforts. It should be noted that, contrary to popular belief, knowledge of the volume of water in the bottle is not necessary.

On the other hand, provided that the regulator is equipped with a pressure sensor, the dive computers allow much more precise calculations. Thanks to this, they determine at any time the pressure variations of the cylinder as well as the pressure itself. (The current pressure sensors are able to measure the variation of HP resulting from a single inspiration of the diver)

As these calculators know how to determine in advance the ideal profile of ascent they can deduce the consumption at each moment and thus calculate the consumption until the outlet of the water.

These calculations are updated, for example, every minute. This eliminates the causes of momentary errors such as the one caused by a fused regulator, the variation of the diver’s forces or a too fast ascent for a few moments.

The calculations are also corrected for ambient temperature to eliminate errors due to the resulting HP variations. As long as the diver remains within the limits allowed by his device, the error of autonomy is of the order of one minute which is sufficient in most cases.

The most interesting result is that these devices are able, in advance, to warn the diver that he may be in need of air.

He can then modify his dive profile to recover sufficient autonomy.

The portage

The bottles are heavy and bulky. From the beginning of the dive, the manufacturers and often the divers themselves have tried to limit the disadvantages. The straps attached to the blocks have practically disappeared. The appearance of the vests allowed to remove them which facilitates their handling and reduces maintenance.

Cylinders are generally worn on the back. However, they can be worn on the front or even laterally. This last solution is a legacy of technical diving and more precisely of underground diving.

The Sidemount

The Anglo-Saxons call it the "Sidemount" in France "Harnais déstructuré" we also call it "Portage latéral". It is still in its infancy for recreational exploration diving.

Many manufacturers have introduced side-lift harnesses that are sometimes associated with an inflatable stabilization system. However, this technique is not yet well developed.

Many divers tinker with simple harnesses which they associate with vests stripped of the back pack and the bottle strap which leaves the back completely free. The harnesses are easy to adjust whatever the morphology of the diver and the configuration of the dives envisaged.

A harness consists of one or more straps on which are arranged rings that allow to fix the bottle: the neck at the armpits and the ass at the level of the belt or in the back.

Fasteners are made by carabiners which make it possible to remove or cap easily. All fasteners are adjustable to find the best balance in water.

The 2 cylinders are generally used alternately in order to maintain a maximum pressure difference defined in advance.

Advantages (equal volume of air taken away):

Carrying under water or out is easier.
It makes the diver's back less painful.
The passage of certain narrows is facilitated.
It is easier to cap or remove the blocks,
It is easier to handle 2 blocks of 9 liters than an 18 liter block,
It is easy to open or close the taps in immersion.
Outside the blocks, the diver's bag is lighter and less bulky.
Blocks and regulators being completely independent, safety is increased.
The position of the blocks under the arms provides better hydrodynamics.
Under the ceiling, there is less risk of damaging the flora or fauna attached.

Disadvantages:

There aren't many of them. In principle, although this type of carrying can only use one bottle, it is mainly used with 2 blocks which has a higher price for purchase and maintenance. Some training is still needed to make the most of it.

TYPE OF VALVES

This is an important element. We use the word taps to refer to equipment that is more complete than a single tap. It is chosen according to the ergonomics of the equipment and in particular the position of the regulator or regulators and the various pipes they are fitted with.

To avoid loading a bottle of 232 bar in DIN, there is a countermeasure. The threaded part in 200 bars is shorter and does not reach the bottom of the tap. If you want to inflate there is a leak. If one wants to mount an operculum the one sinks deeper than normal and one cannot without leakage connect a caliper.

Notes:

We chose to study two taps that present the 2 main designs on the market. We call them (A) and (B)

- Valve (A), photo and drawing has 2 valves. Valves are upstream type during use. Once closed, they avoid water or particles entering their mechanism. On the other hand, it is dangerous to disassemble them if the bottle is not perfectly empty.

- The soft part of the dampers is pierced by a hole in its middle. If air passes behind this part, it is not ejected by decompression when the cylinder is opened.

The clearance between the flap threads allows pressurized air to pass to the rear. It is then said that the flap is balanced. In this way, the thread does not undergo any effort during its rotation which reduces its wear.

- The valves (B), photo and drawing, also have 2 valves. The valves are of the downstream type during use. Even closed, water can penetrate their mechanism but they can theoretically be disassembled inflated cylinder.

It is nevertheless preferable to empty a cylinder completely before intervening on the valve.

Each valve has 2 side grooves that allow pressurized air to pass to the rear. It is also balanced. (See valve views in the burst mechanism)

However, it should be noted that the threaded portion of the cylinder neck connection does not have a safety vent hole. It’s too bad, but probably at the time of its conception, the standard that imposes it today had not yet come out.

On these two valves, the presence of a "Plunger Tube" is noted, the role of which is to prevent that, when the valves are down, impurities contained in the bottle can pass through the valves and towards the regulators. (On the other hand, a plunger tube prevents the emptying of water that could have penetrated the bottle incorrectly)

See also at Beuchat le SAS: "Safe Air System". These are 2 completely independent taps included in the same body with 2 plunger pipes and 2 outlets.

The standard for DIN 300 bars is the DIN477/50. For an International caliper in 232 bars it is the CGA850. Note the new standard EN144-33 which is supposed to avoid filling, with a polluted gas (in particular with oil) blocks reserved for mixtures on oxygenates. This standard provides for a connection that resembles the "DIN" although the dimensions are larger and the thread is always metric.

The choice of a double tap is made because of the regulations in force, at least in France. It should be noted that the reliability of a double connection, although sufficient, is approximately 2 times less than that of a single connection.

In other words, you are twice as likely to see a joint leak, if there are two instead of one. This regulation was established at a time when the first floors were unable to supply 2 second floors.

However, there are two good reasons to use a double valve with two full regulators: First, two second stages are not always perfectly compatible between them either because they are different or because they do not have the same setting.

Then and this is important, two valves allow to close the side of the defective regulator for example in case of continuous flow or icing.

The solution, admittedly imperfect, is to be able to perform this maneuver, alone and quickly. (In less than 15 seconds a bottle, wide open, loses about half of its capacity)

The method, in the event of a major leak, is to loosen the lap belt in "Velcro" of the vest, pull it over the head, catch the valve and close the right valve. This is easy to say, but it can only be done properly if you practice ahead of time. (Notice to Instructors)

The "Side Port" solves the redundancy problem with two independent blocks and each one regulator rather than a 2-valve valve on a single block.

Apart from the 2 seals of the operculum, when using a caliper, a valve uses at least 3 o-rings:

- A joint between the valve body and the bearing that some call the “Stuffing Press” It prevents leakage between these 2 fixed parts.

- A joint on the screwdriver rod prevents the leakage of the HP between this rotating rod and the bearing. The joint works the most. A teflon anti-extrusion ring is sometimes added. It is sometimes replaced by a flat teflon seal.
- Another seal on the tail of the screwdriver rod prevents water from entering the gap between the screwdriver rod and the bearing. This seal is only subjected to ambient water pressure.

See seals treated with regulators. It will be recalled that with the "DIN" the joint holds better, even if for the stirrups and an operculum the hold has improved well in recent years.
The seal joints
Internal dimensions and diameter of section in millimetres.
R9: 10.5x2.70 – Outer side of the operculum
R10: 12.1x2.70 – Inside side of the operculum?
ISO standard: 10,77x2,62 - Shore hardness DS/A =90. (Both joints are identical)
Blocking of the operculum
This problem may be encountered when switching from a U-connection to a DIN connection or vice versa. We therefore felt it necessary to develop it.

- Blockage due to shock

The valve is exposed to shocks that can cause deformation that will prevent you from removing or setting up the operculum or regulator. The valve heads must therefore always be protected by mounting screwed inserts when there is no seal in place.

Technical divers use protections that additionally protect the opening flywheels.

Some brands provide reinforced taps that we cannot recommend too much. Aqualung’s initiative to strengthen its Y-valves to avoid this inconvenience will be welcomed. On the other hand, does it allow you to receive all the stirrups on the market?

Nevertheless, shocks must be avoided at all costs. Apart from dives, these often occur when the blocks fall or when lying down, when loading into vehicles or on a boat.

- Blocking by deposition of salt or limestone

It is a common cause of blockage of the operculum in its housing. It comes from the accumulation of salt and limestone in the thread. It is not protected by seals.

When the water is immersed, it enters. At the exit, the water evaporates leaving a deposit that after a number of dives ends up blocking the operculum. In this case, if you do not want to permanently damage the valve, it is necessary to entrust the dismantling of the operculum to someone competent.

"But prevention is better than cure".

Fifteen centimeters or 2 turns of teflon ribbon 1/10e,

coiled in the same direction as the threads of the operculum, are sufficient to protect them.

See photo N°4

(Tested successfully since 16/01/2016)

Drain the valves

Remember that the presence of water in a poorly purged tap is the main cause of corrosion in a steel cylinder. (1 gram of water = 1cm3)

For example, when you rinse your bottle the faucets can fill with water. The average quantity that a valve can hold is about 0.3 cm³, or more depending on the model. If you do not purge it before inflation, this water ends up in the bottle. What happens to it?

Consider a compressor that supplies air to a 10-litre cylinder. The Regnault table tells us that at 30°C a volume of 1m3 (1,000 litres) can contain 30 grams of water vapour without condensing.

So the 10 liters of our bottle can hold 0.3 gr of water vapour.

At the first inflation, if the valve has not been purged, 0.3 cm3 (0.3 gr) of water will end up inside and vaporize.

At the second inflation it remains for example 1/5 of the air which had been accumulated in the cylinder so 1/5 of the steam is 0,06 gr. If you make the same mistake, you'll have 0.36 grams of water in the 10 litres and 0.06 grams condense. And so on—

It should be noted that upstream valves can accumulate 5 to 6 times less water, which is less harmful.

Flushing the valves is essential to prevent corrosion of the steel cylinders.

Also, the presence of water is an important cause of icing and therefore of accidents.

However, if a lot of water has penetrated the bottle, for example if you emptied a bottle without a regulator to inflate a parachute, the plunger tube will prevent it from emptying it completely, even when turning it over. It is better to remove the faucet to empty and dry it.

Notes:

- A downstream valve can be distinguished from an upstream valve without disassembly. In an upstream valve, the flywheel and the outlet are almost on the same axis, while in an downstream valve, the axes are shifted to 90°.

- In principle, after a dive, there is always air left in the cylinders and this should be sufficient to allow purging before the new inflation.

If a bottle is emptied, the valve cannot be purged. If, for any reason, water is in the cylinder, at the next inflation it will enter the cylinder and cannot be removed from it. (The plunger tube opposes it)

It is then necessary to disassemble the valve to empty this water and dry the inside of the bottle before reassembly and the next inflation...

This problem can also arise if the valve is not properly closed after a dive.

Tip: During a dive, never empty a bottle completely.

Maintenance

- The block

Daily maintenance

Après chaque plongée, elle peut se faire au jet d'eau douce. Mais elle est plus efficace au trempé car elle nettoie le cul sous sa protection. Dans ce cas, elle peut même se faire avec le détendeur monté, ce qui évite les entrées d'eau.

The yearly maintenance

It consists mainly of a visual inspection by a “Visual Inspection Technician” (TIV). It must be completed every 6 years by requalification, which mainly consists of a pressure test. On this occasion it may be necessary to redo the surface treatment and/or painting.

- The valves

Its operation is inspected during the "Visual Inspections". The seals of the seal and the seal with the cylinder can be replaced. Interior seals can also be replaced but this must be done by a qualified technician. This operation can be done with the valve mounted on the bottle but in any case, it is imperative that it be emptied.

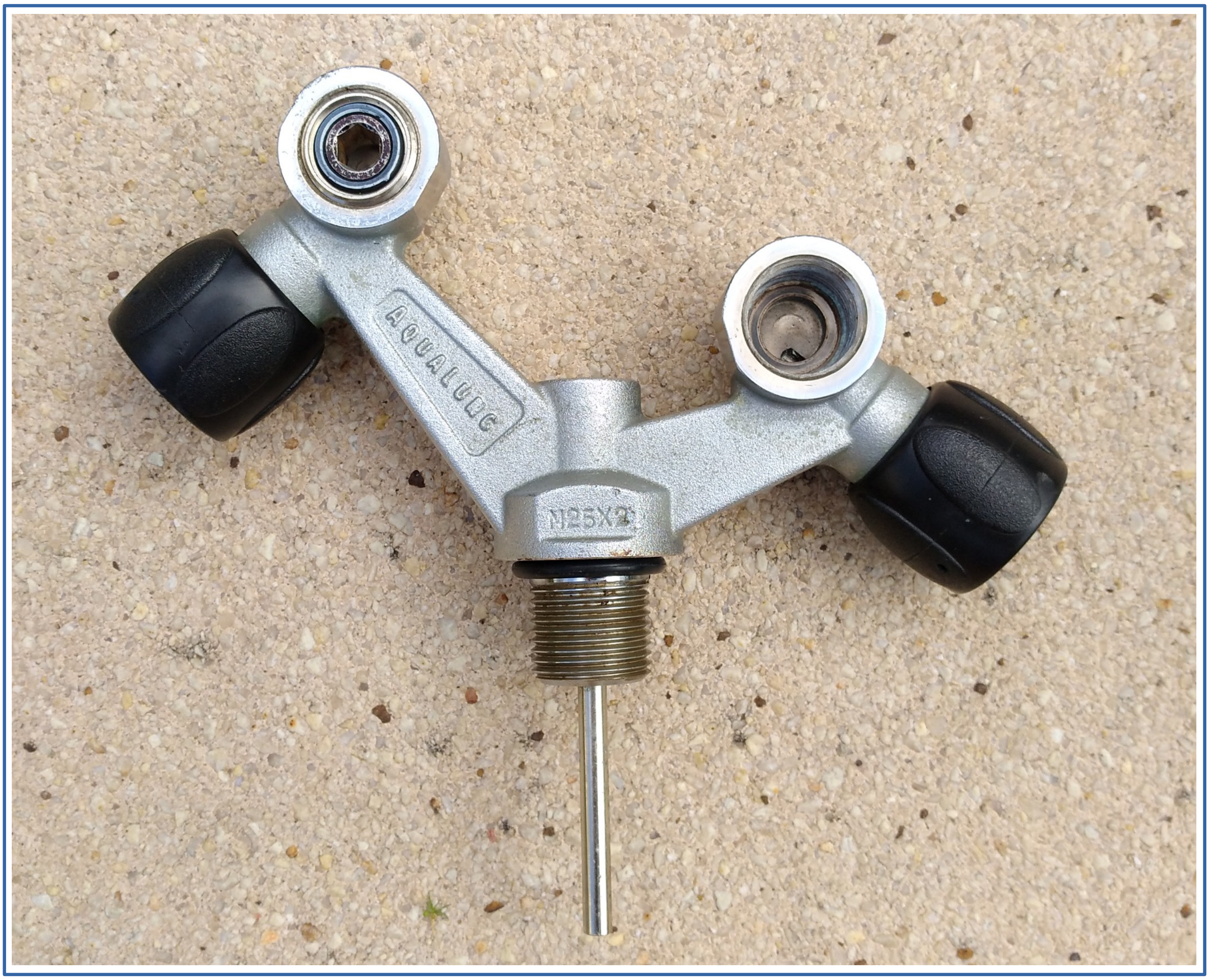

Figure 1 ***Robinetterie à 2 sorties (Modèle TAG2 Aqualung)***

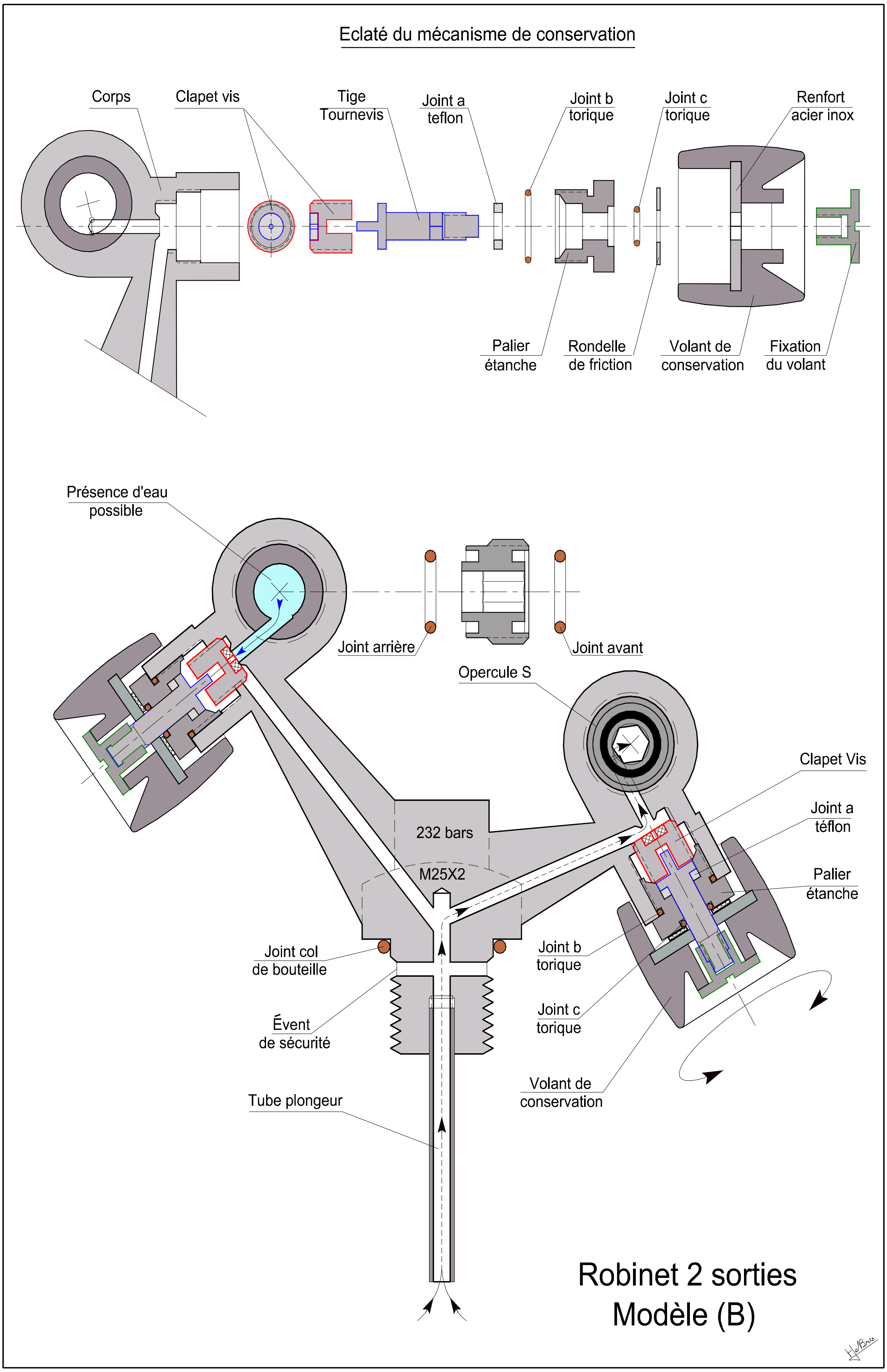

Figure 2 ***Robinetterie à 2 sorties TAG2 (Détails)***

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Figure 4 ***Opercule téfloné***

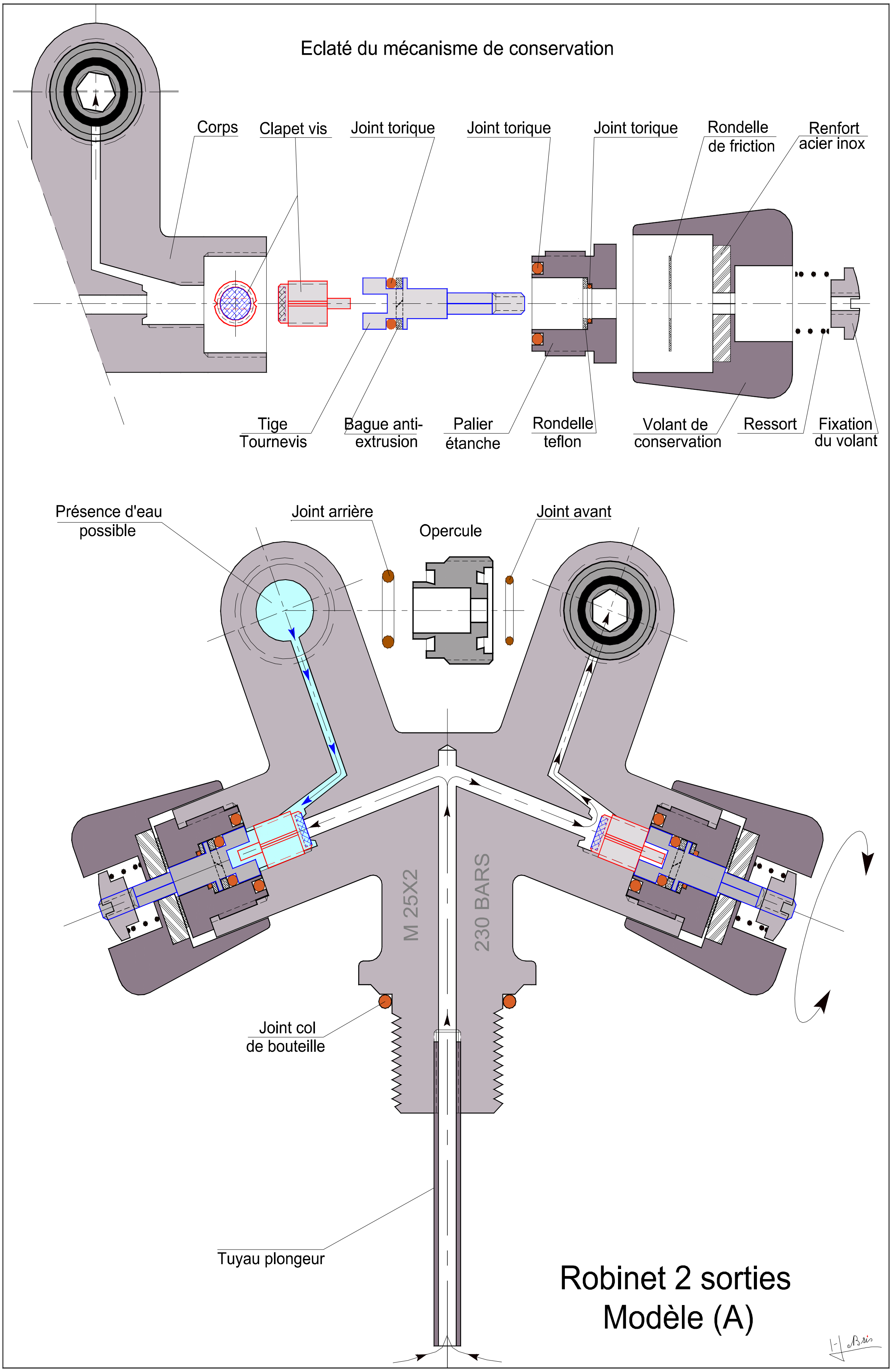

Figure 5 Beuchat 2 outlet valves

QUESTIONS

In order to participate in the training of our visitors, we offer them answer a few questions.
1) What are the advantages and disadvantages of water inflation?
2) Advantages and disadvantages of "Lateral or Sidemount"?
3) Why is it important to properly purge the valves before inflation?
4) Compare the advantages and disadvantages of caliper or DIN connections?
5) What preventive measures can be used against opercular blockage?
6) Why should inflation speeds be limited?
7) What is maintenance of blocks, fittings?
8) What are the important markings on a faucet?
9) Why not completely empty a cylinder between two inflations?

a) Try to answer them before searching this site.
b) At what level of diver do you place these questions?

ANNEX

Material	Volume in Water	Diameter mm	Lengh	Pressure	Volumes of air	Weigh
Steel	12 liters	171	650	200 bar	2,400 m3	12,80 kg
Steel	12 liters	171	"	232 bar	2,784 m3	14,40 kg
Steel	12 liters	171	"	300 bar	3,600 m3	18,30 kg
Steel	15 liters	171	"	232 bar	3,480 m3	17,40 kg
Steel	12 liters	203	"	200 bar	2,400 m3	14,10 kg
Steel	12 liters	203	"	232 bar	2,784 m3	15,20 kg
Steel	15 liters	203	"	232 bar	3,480 m3	18,60 kg
Aluminium alloy	12 liters	204	615	200 bar	2,400 m3	16,60 kg
Aluminium alloy	12,2 liters	204	610	232 bar	2,830 m3	16,48 kg
Composite						

Characteristics of some bottles in the market

It should be noted that the air volumes above do not take into account the compressibility factor of Mariotte's law.

Guest-book

XiTi