1. The filter body

The filter bodies come in three different materials: PVC (PolyVinyl Chloride), AISI 316L (stainless steel) and GRP (Glass-fiber Reinforced Polyester). Filter bodies in PVC and GRP have very good corrosion resistance, which makes them suitable for salt water. Stainless steel is suitable for fresh water.

Figure 1.1. From left to right: PVC, GRP and AISI 316L

Filter type	Filter body material	Max pressure	Max temperature
BSP	PVC	150 psig	104° F , 40° C
BSG	Glass Reinforced Polyester	90/150 psig	140°F , 60° C
BSS	Stainless Steel AISI 316 L	150 psig	176° F, 80° C

Table 1.1. Our different filter body materials

The filter sizes are given in the American standard: ANSI (American National Standards Institute). Instead of millimeters they are measured in inches in sizes as follow.

2.5" 3" 4" 6" 8" 10" 12" 14" 16" 18" 20" 24" 28"

The filter sizes are given by the nominal diameter (DN) in millimeters of their connections (inlet diameter = outlet diameter). This standard is called “DIN” (Deutsches Institut für Normung), which is Germany’s standardization organisation (used in most parts of the world). The sizes range from DN 65 to DN 700:

Our range of filters in DIN is the same as in the ANSI standard, converted as follows:

65 80 100 150 200 250 300 350 400 450 500 600 700

The ANSI and DIN standards are our most common standards, but not our only ones. Any other flange standard can be applied on request. Differences between the standards include the thicknesses of the flanges and the bolt patterns.

Depending on the operating pressure, our filters are manufactured in different classes. These classes are called “Pressure Norms” (PN). A filter can, for instance, be manufactured in PN 10. This means that the filter’s maximum operating pressure is 150 psig. The maximum pressure shown includes a large safety margin. Our standard filters are manufactured in PN 6 and PN 10 but any other norm can be applied on request.

Furthermore, there are two small connections marked “A” and “B” near the inlets of the filters. Water tubes connecting to the differential pressure switch are attached to these holes.

The end covers (the lids of the filters) for our larger filters are globed. This is because a globed end cover bears pressure better than a flat one.

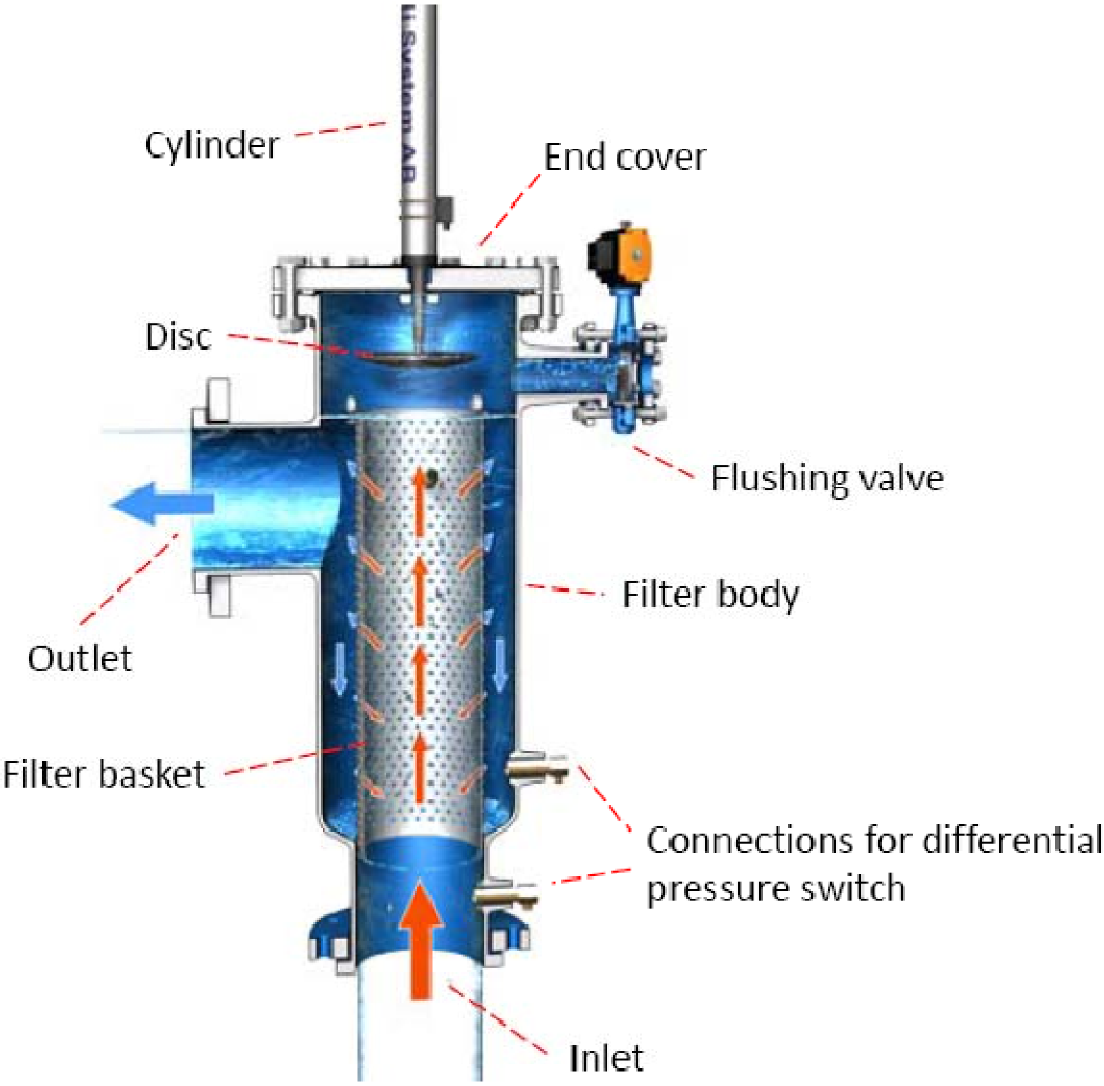

Figure 1.2. The filter with its main components

2. The filter basket

The Bernoulli System delivers three types of baskets: perforated, wedge-wire and expanded metal (see Figure 2.1). The basket materials are stainless steel (AISI 316 L) or titanium. For manufacturing reasons, titanium baskets are available only in perforated forms.

The openings in perforated baskets are round holes.

Wedge-wire baskets are made up of thin rods with a triangular cross section. Between the rods thin openings are formed in stripes. Support rods hold the thin rods in place. The rods are located on the outside of the basket.

Expanded metal is used for our finest filtration degree, 0.1 mm. The mesh has very small openings in the form of four-cornered diamonds. The filtration mesh needs a support mesh for strength.

Figure 2.1. From left to right: perforated, wedge-wire and expanded metal

The filtration degree ranges from 2.0 mm down to 0.1 mm. Our basket with the finest filtration degree can be seen in Figure 2.2.

Figure 2.2. An expanded metal basket with a filtration degree of 0.1 mm

We have listed product ranges for our different types of baskets in Tables 2.1, 2.2 and 2.3. These tables show the open areas for the filters. The “open area” is the area in the filter basket’s wall through which the water can flow, divided by the whole area of the basket wall. When the basket is clean, the open area in our baskets is between 20 and 50 percent, depending on the basket type it is. As more and more dirt is collected in the basket, the open area decreases. The figures in Tables 2.1-2.3 correspond to clean baskets.

Material	**Filtration degree**	**Open area**
AISI 316 L	1.0 mm	31 %
AISI 316 L	2.0 mm	31 %
Titanium	1.0 mm	31 %
Titanium	1.5 mm	31 %
Titanium	2.0 mm	31 %

Table 2.1. Our range of perforated baskets

Material	**Filtration degree**	**Open area**
AISI 316 L	0.2 mm	21 %
AISI 316 L	0.3 mm	23 %
AISI 316 L	0.5 mm	38 %
AISI 316 L	1.0 mm	50 %

Table 2.2. Our range of wedge-wire baskets

Material	Filtration degree	Open area
AISI 316 L	0.1 mm	25 %

Table 2.3. Our range of expanded metal baskets

The basket is inserted into the filter body according to Figure 2.3.

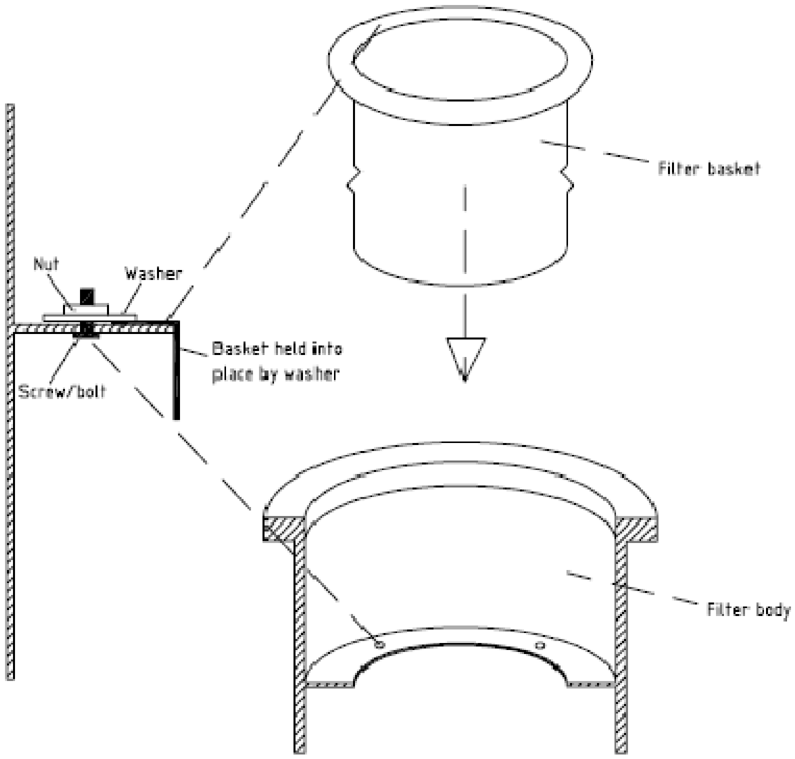

Figure 2.3. How the basket is inserted into and attached to the filter body

The figure shows how the flange of the basket is put on the inner flange of the filter body. The gap between these two is never larger than the filtration degree, so there is no need for a gasket there. At the other end of the basket, near the filter's inlet, the situation is the same. Here the basket end is slightly coned so it can slide smoothly into the filter inlet. The gap formed here is never larger than the filtration degree either, except for our baskets with a filtration degree of 0.3 and finer. For those baskets an o-ring is used as a gasket.

3. The cylinder with its disc

The cylinder is attached to the end cover. Inside the cylinder is a cylinder rod. The disc, which creates the Bernoulli effect, is attached at the end of this cylinder rod. Larger filters have a double disc instead of a common single one. This helps minimize vibrations.

Figure 3.1. A cylinder with its disc for one of our smaller filters. At the ends of the black cords you can see the limit switches.

Figure 3.2. The disc for a BSG 200

The cylinder is driven with compressed air which passes in and out through two connections on the cylinder. One connection is above the upper limit switch, one is below the lower limit switch. A magnetic piston is attached to the cylinder rod (see Figure 3.3). Compressed air comes in to the upper connection, fills up the void, and presses the magnetic piston and the cylinder rod down.The cylinder rod moves into the filter basket. When it goes up again compressed air comes in to the lower connection, fills up the void, and presses the piston upwards.

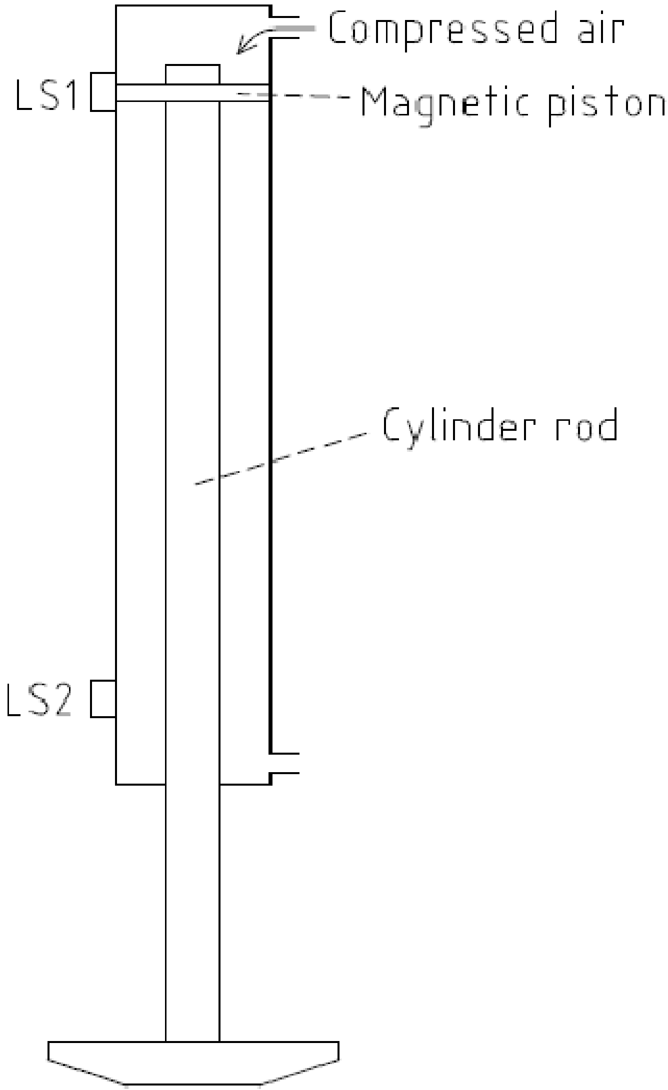

Figure 3.3. A schematic picture of the cylinder. The proportions in the figure are not correct.

The piston must recognize its limit positions so it knows when to stop and go back. This is where the limit switches come into the picture (see Figure 3.3 and 3.4). The limit switches are attached on the outside of the cylinder. They decide the cylinder stroke's end positions. The distance between the limit switches is approximately 2/3 of the basket's length. The limit switch situated at the top end of the cylinder is called LS1;the one further down is called LS2.

Cords attach the limit switches to the control box. When the magnetic piston moves downwards (see figure 3.3), it will eventually reach LS2. Because the piston is magnetic it will then close an electric circuit. The control box will then know that it is time to stop delivering air into the upper connection. Instead it signals that it is time to start delivering air into the lower connection. The piston and the cylinder rod will then move upwards. When the magnetic piston reaches LS1 the same events will take place there . The compressed air then pushes the piston downward again.

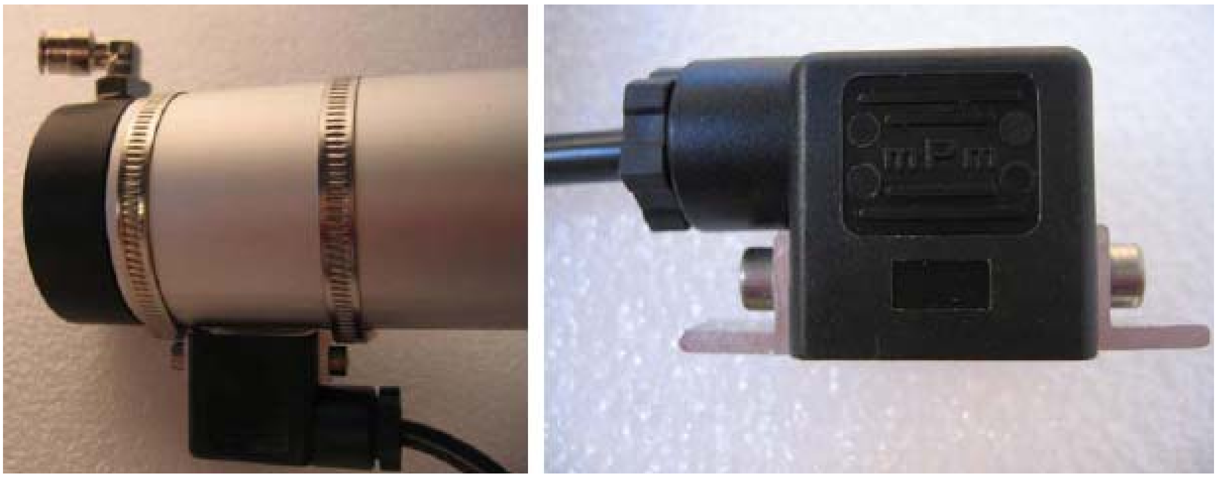

Figure 3.4. A limit switch

Only the cylinder rod comes into contact with water. The surrounding aluminum part of the cylinder is sensitive to water, so it is very important that no water gets inside the cylinder. When aluminum comes into contact with water it oxidizes. Oxidized aluminum is very brittle. As such, the walls inside the cylinder cannot seal in the compressed air which drives the cylinder. In other words, no pressure can be built up and no strokes of the cylinder can be achieved.

Our filters contain a plastic hub. It is placed in the opening of the end cover. The hub prevents water from passing through to the inside of the cylinder, as there are u-seals in the hub.

As a safety measure, there is a part called a flower between the hub and the inside of the cylinder. The flower creates distance between them so that they are never in direct contact. Thus if the u-seals in the hub are worn out, water will not come into contact with the inside of the cylinder, but will flow away through channels located in the flower. When this happens it is time to replace the u-seals in the hub. Our small filters do not have a flower. Instead they have a drainage hole drilled into the hub. This hole has the same function as the flower.

4. The flushing valve

The flushing valve is closed during normal operation. When the filter is being flushed clean of dirt particles, the flushing valve opens and the particles are swept away.

Our small filters have ball valves: the larger ones have butterfly valves (see Figure 4.1).

Figure 4.1. A butterfly valve (left) and a ball valve (right)

There must be a pressure difference between the inlet of the filter and the drain. Otherwise the Bernoulli effect does not occur. This difference varies with the basket size and type. The lowest difference required is 5 psig.

Sometimes a big pressure difference exsits between the inlet of the filter and the flushing channel. In those cases the filter is often equipped with an orifice in the flushing channel to limit the flushing flow.

Figure 4.2. Different types of orifices

5. The differential pressure switch

Plastic tubes are attached in the small connections near the filter inlet on the filter body (see figure 5.1). These two tubes lead to the differential pressure switch. One of the tubes takes water from the inside of the filter basket (dirty water, connection A) while the other one takes water from the outside of the basket (clean water, connection B). The water in the two tubes will consequently have different values in static pressure. This difference depends on how many dirt particles have collected in the basket, i.e. the clogging degree. At normal conditions the static pressure is higher on the outside of the basket. This leads to a reversed flow at the filter inlet. When the basket has been clogged the relationship is the opposite. The reversed flow will thereby end.

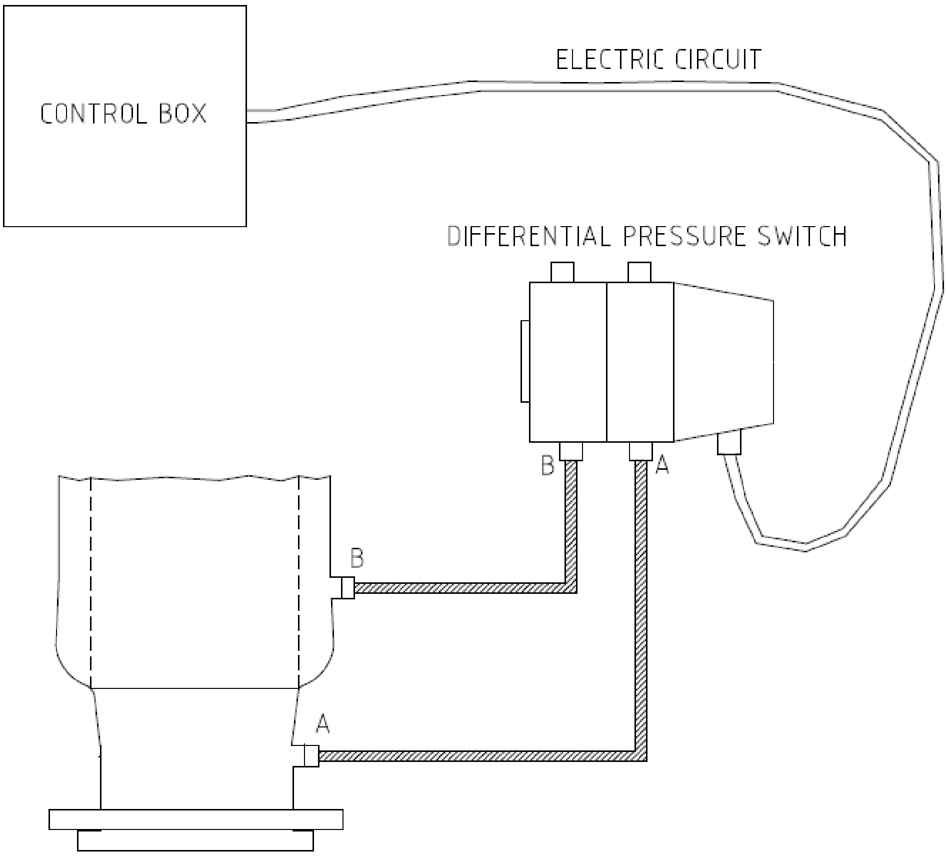

Figure 5.1. The inlet part of the filter with connections A and B. The electric circuit will be closed when the pressure at A is 1.6 psig higher than the pressure at B.

Figure 5.2. The differential pressure switch (left)and one of the connections on the filter body(right)

The differential pressure switch contains a mechanism that can sense this difference in pressure. The mechanism consists among other things, of a magnet and a membrane. When the preset difference (1.6 psig) has been reached, an electric circuit between the differential pressure switch and the control card is closed and the control card starts a flushing sequence.

6. The control box

The control box can be seen in Figure 6.1 with its electronic card in Figure 6.2. In this case the electronic card has all three functions: T1, T2 and T3 (T3 is optional). The card also includes the optional display.

With T1 the time between flushings is set. You can choose intervals from 7 minutes to 48 hours. When the filter is delivered, T1 is set to 1 hour.

T2 decides the pre-flushing time, i.e.how long the flushing valve will be open before the cylinder starts making its strokes. This enables large particles to be flushed out so that they do not get stuck between the disc and the basket wall.

T3 is only of interest if you have multiple filters installed in parallel. With this function you can set the time between the starts of the flushings for your filters so that they don't all start their flushing sequences at the same time.

An optional digital display placed on the electronic card counts down until the next pre-set flushing and counts the number of flushings performed.

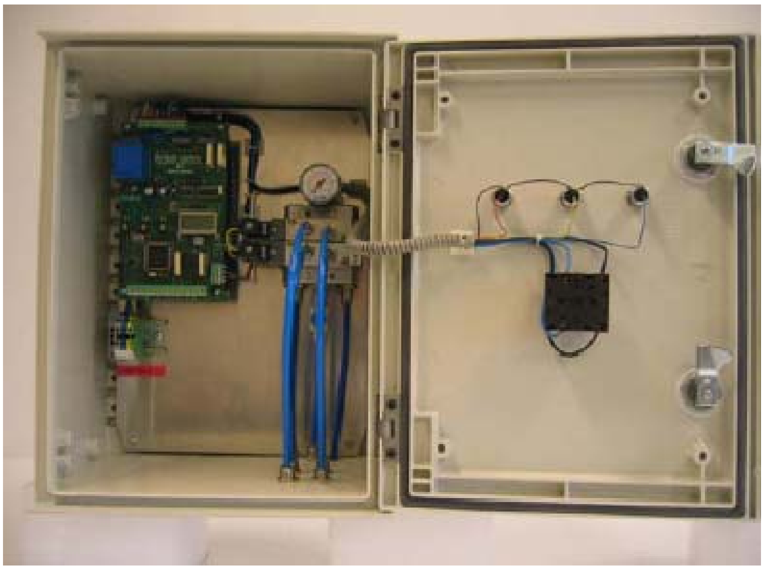

Figure 6.1. The control box

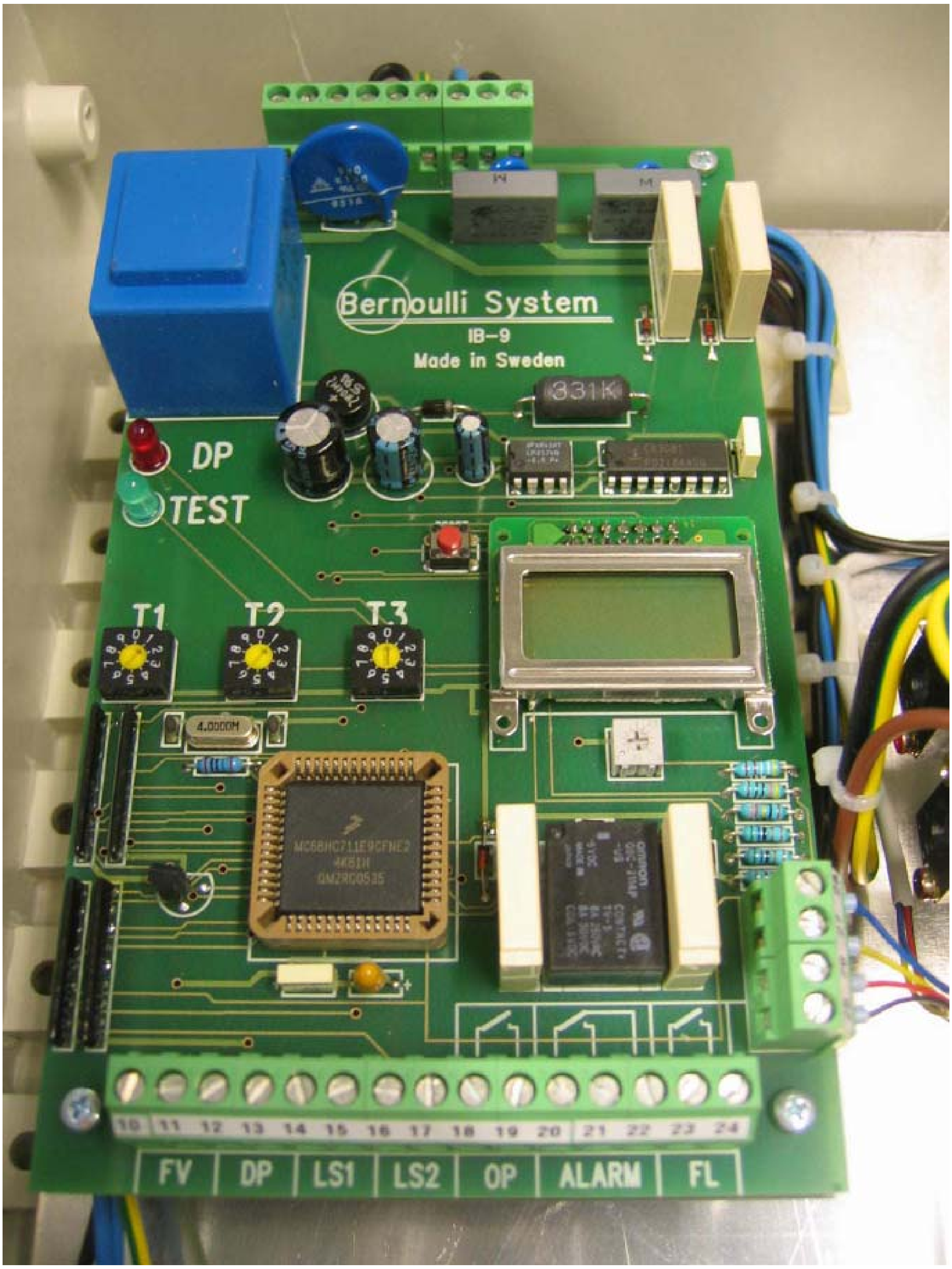

Figure 6.2. The electronic card with T3 and a digital display

7. Solenoid valves

Our filters are operated by compressed air. The cylinder has a connection at the top and another at the bottom (see Figure 3.3). Which connection the air comes into determines if the piston goes up or down. The flushing valve is also operated by compressed air. One of the air tubes leading in to the valve is for opening the valve, the other one is for closing the valve.

The compressed air enters the system through the control box (connection "P" in Figure 7.1) and is directed to two solenoid valves (see Figure 7.1, to the right). These valves control where the air is distributed. Inside the valves are gates that can be closed or opened, leading the air to different connections/ports (see Figure 7.1, to the left). Electric signals from the electronic card tell the valve which gates to close or open.

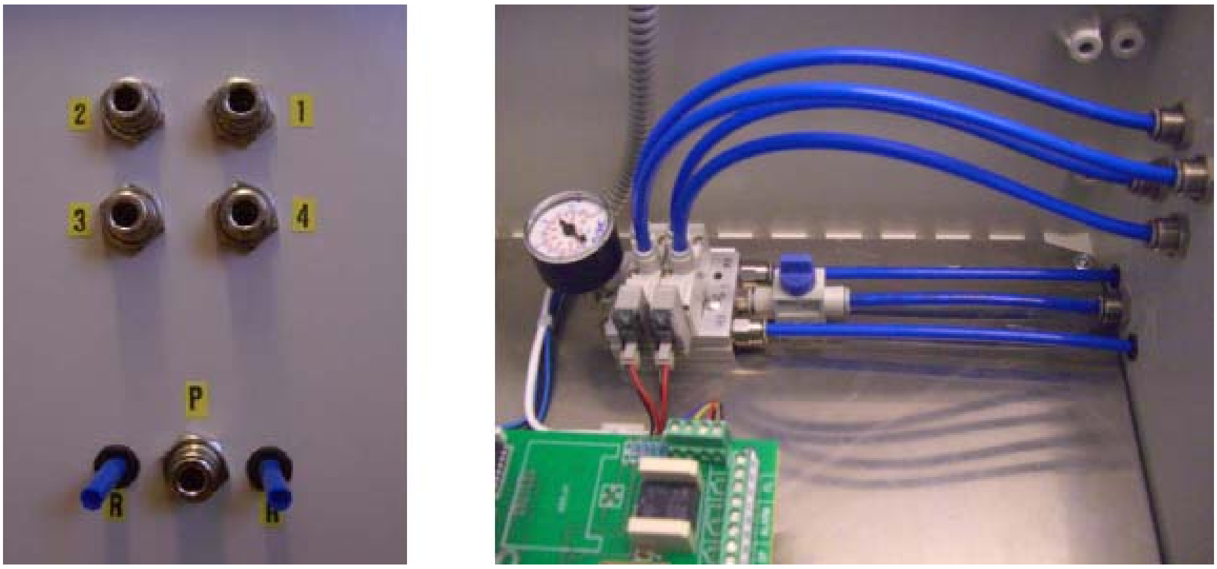

Figure 7.1. Left: the air connections on the bottom of the control box
Right: The tubes inside the control box and the two solenoid valves

In Figure 7.1, connections 1 and 2 msut be connected to the cylinder, whose connections also are marked "1" and "2". Connections 3 and 4 shall be connected to the flushing valve's connections, also marked accordingly.

The air that has been used by the filter leaves the system through the connections marked "R" in Figure 7.1. One connection is for air used by the cylinder and the other is for the air that has been used by the flushing valve. Some filters are equipped with air releases directly on the cylinder ports to enable quicker cylinder strokes.

The air consumption for our different filter sizes is given in table 7.1. The volumes and volume flows are calculated at 68° F (20° C) and atmospheric pressure.

Filter size	Standard cylinder	Peak flow [l/min]	Total volume per flushing [l]	Approx. flushing time [s]	Average air consumption [l/min] **	Minimum compressor [kW]	Minimum receiver [l]
65	40	120	5	15	0.1	1.5	25
80	32	120	6	20	0.1	1.5	25
100	32	120	7	20	0.1	1.5	25
150	50	180	20	30	0.3	1.5	25
200	50	180	23	30	0.3	1.5	25
250	80	240/350*	80	45/27 *	1.3	1.8	50
300	80	240/350*	90	45/27 *	1.5	1.8	50
350	100	350	160	35 *	2.7	2.2	100
400	100	350	160	35 *	2.7	2.2	100
450	125	350	330	55 *	5.5	2.2	100
500	125	350	330	55 *	5.5	2.2	100
600	160	350	550	100 *	9.2	3.0	200
700	200	600	1150	150 *	19.2	4.2	500

* With air release directly on cylinder ports. Optional for sizes 250 and 300.
** Assuming one flushing per hour.

Table 7.1. Air consumption for various filter sizes