

FILTRATION

TECHNICAL INFORMATION 1

FILTRATION EFFICIENCY AND PARTICLE COUNTER

Filtration efficiency

The filtering efficiency (or retention power) of a filter is defined as the ratio between the number of particles retained, divided by the number of particles entering the filter itself.

$$\varepsilon = \frac{N^{\circ} \text{ Retained Particles}}{N^{\circ} \text{ Inlet Particles}} \%$$

In practice, are measured the particles entering and leaving the filter. Those retained are calculated as the difference between these two values. It is therefore possible to write:

$$\varepsilon = \frac{N^{\circ} \text{ Retained Particles}}{N^{\circ} \text{ Inlet Particles}} = \frac{N^{\circ} \text{ Inlet Particles} - N^{\circ} \text{ Outlet Particles}}{N^{\circ} \text{ Inlet Particles}} =$$

$$\varepsilon = \left(1 - \frac{N^{\circ} \text{ Outlet Particles}}{N^{\circ} \text{ Inlet Particles}} \right) \%$$

Filtration efficiency

Generally the filtration efficiency can be indicated in two ways:

- Nominal $\varepsilon < 99.98\%$ (e.g. 95%, arbitrarily chosen by the company)
- Absolute $\varepsilon \geq 99.98\%$

Why exactly the 99.98% value? The BETA β Ratio

β is defined as the ratio between the number of Inlet Particles (having a certain diameter) divided by the number of Outlet Particles:

$$\beta = \frac{N^{\circ} \text{ Inlet Particles}}{N^{\circ} \text{ Outlet Particles}}$$

example:

at the Inlet of the filter we have 50,000 particles;

We only have 10 particles at the Outlet;

$$\beta = \frac{50'000}{10} = 5'000$$

if we now apply the definition of efficiency seen previously:

$$\varepsilon = \left(1 - \frac{N^{\circ} \text{ Outlet Particles}}{N^{\circ} \text{ Inlet Particles}} \right) \% = \left(1 - \frac{1}{\beta} \right) \% = \left(1 - \frac{1}{5'000} \right) \% =$$
$$\varepsilon = 99.98 \%$$

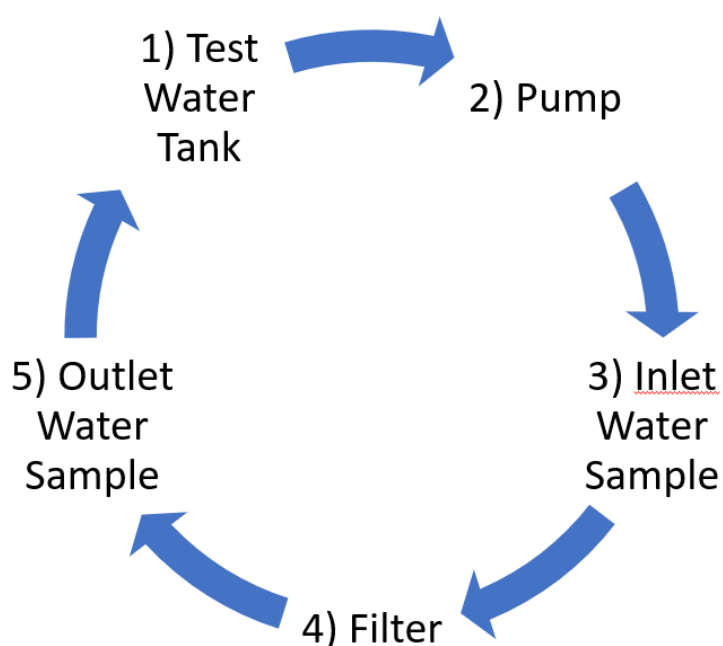
masters of filtration

In simple words: with an efficiency of 99.98%, only 1 particle for every 5,000 Inlets (for a given diameter) can pass through the filter.

Everblue test procedure

In order to test the filtration efficiency of Everblue cartridges, an internal test procedure was developed.

It provides for the use of a closed circuit hydraulic system, consisting essentially of the following components and a particle counting machine.



The water inside the tank is mixed with powders with a specific particle size. The water will then be pressurized by the pump through the filter, returning inside the tank.

At the inlet and outlet of the filter there are two points from which the two samples, IN and OUT, are taken, which allow the calculation of efficiency with the procedure seen above.

Particles counter machine



PAMAS S4031

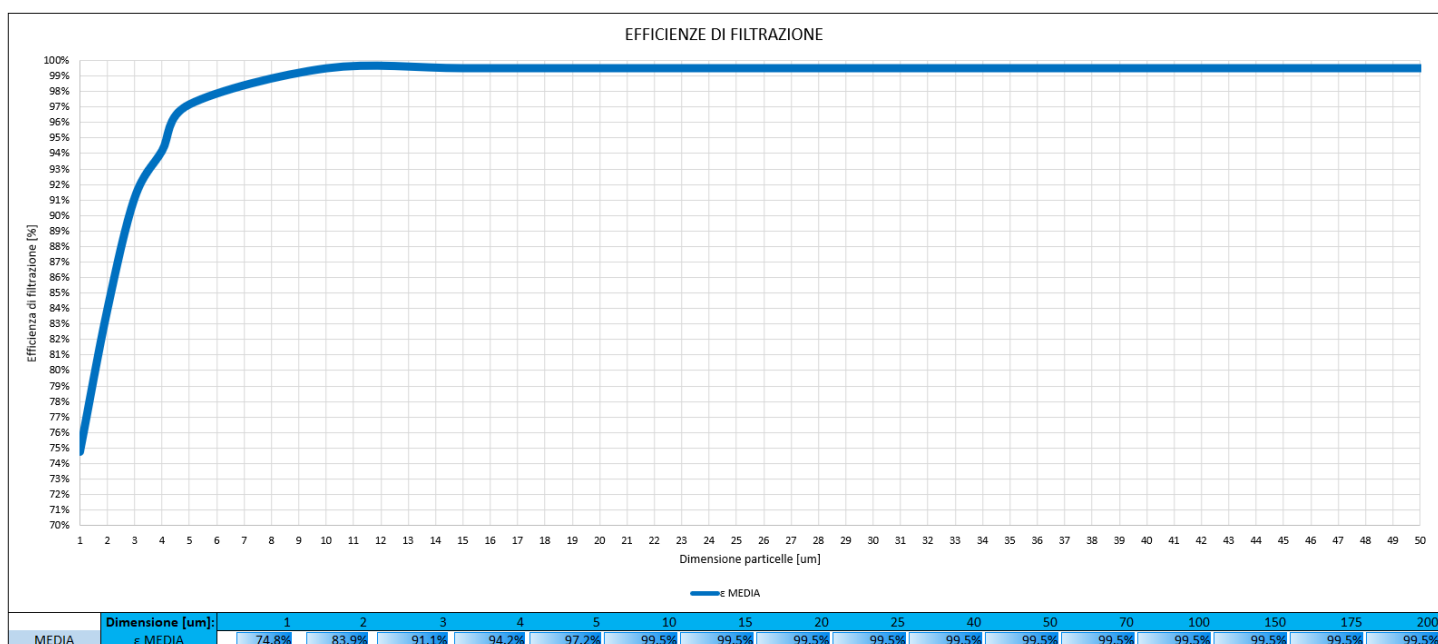
The **PAMAS S4031** is a portable particle counter for liquids. It is used for research and standard measurements in laboratories and test institutes and is adequate for indoor and field applications. The instrument can be applied for batch sampling or for online measurements. A wear resistant ceramic piston pump guarantees a constant flow. With a simple-to-use touch screen user interface, operation is easy and intuitive. Up to 32 free adjustable size channels may be selected and stored in the system. The system is equipped with an integrated battery for more than 3 hours operation and data storage of more than 4000 measurements.

Applications

- Process water, waste water and potable water
- Organic fluids
- Corrosive fluids
- Parts cleanliness control

For counting the number of particles in the Inlet and outlet samples, a machine is used that provides data in .txt format importable in a spreadsheet.

After some reworking, the results obtained are of this type:



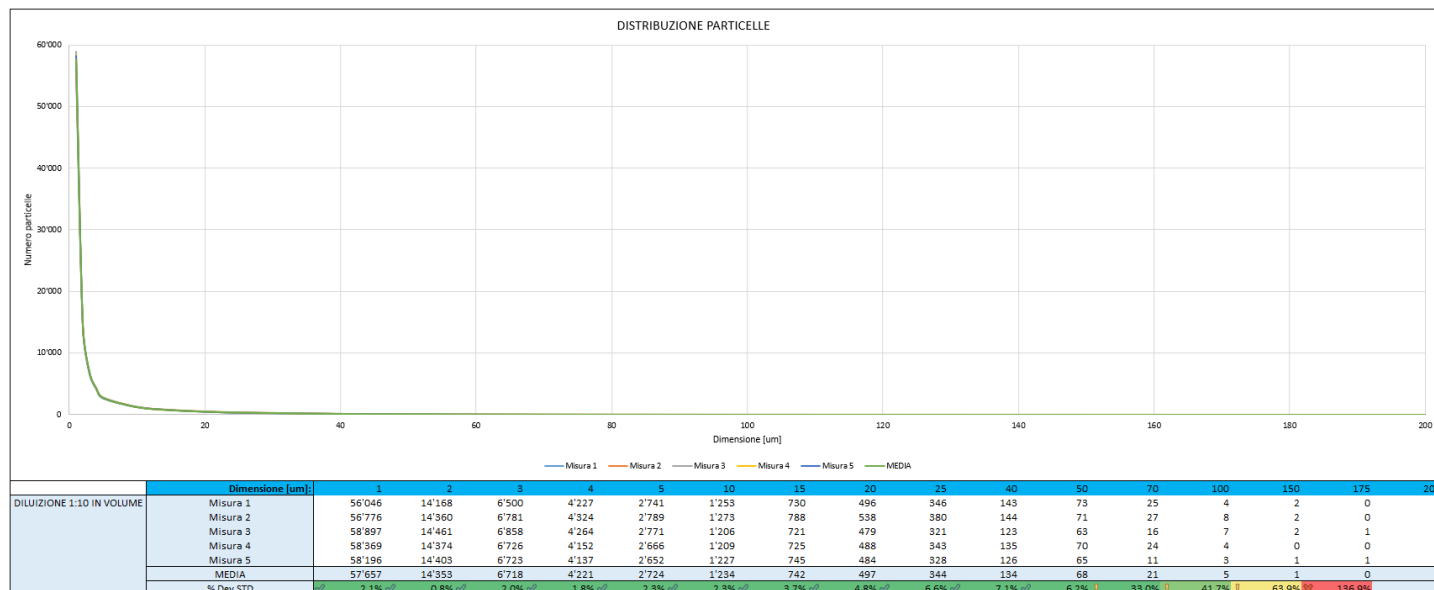
The efficiency curve is approximately continuous and assumes gradually increasing values.

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The nominal grade of the filter cartridge is chosen on the basis of the first efficiency value that exceeds the useful level. In this case the cartridge is a 5 µm nominal at 95% (97.2%).

Particle distribution

This second graph shows the number of particles of the incoming water IN in order to determine the most performing filter cartridge.



From this result it would seem that there are many small and less and less particles with larger diameters, with a curve similar to a hyperbola.

Instinctively one could say: "many small particles, I put a very high efficiency 1 or 5 µm filter".

The solution is obviously wrong and we immediately see why.

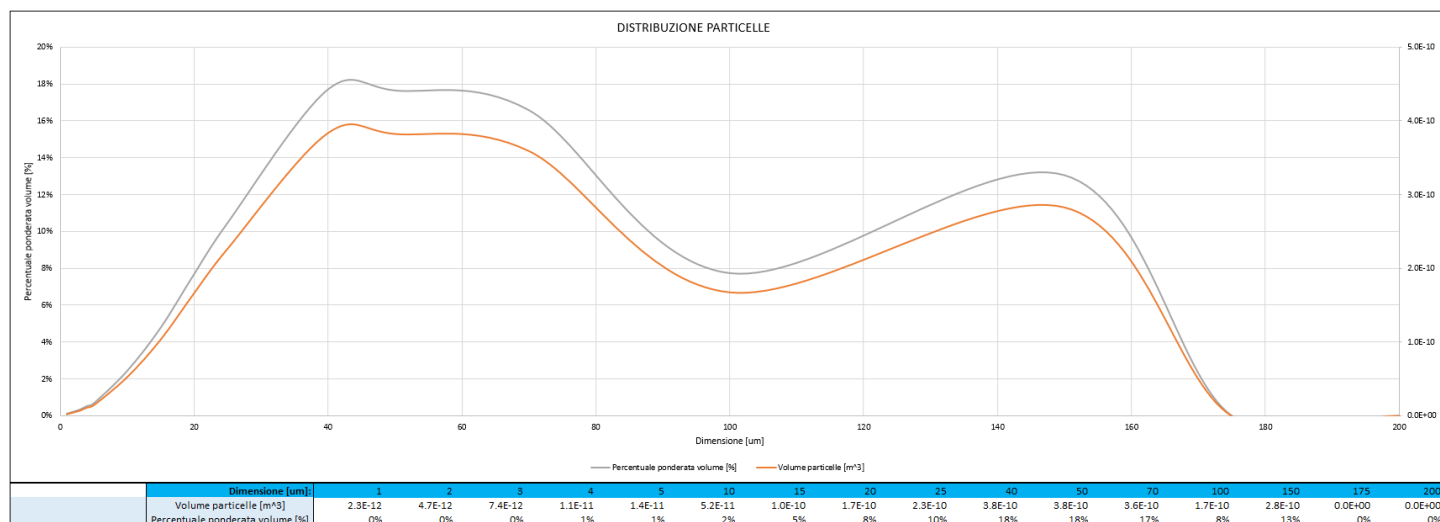
First of all, remember that the ability of a filter cartridge to retain suspended solids is not measured in number of particles, but in the volume retained. This volume is a function of the filtration efficiency, so a very high efficiency cartridge can retain little volume of suspended solids.

So if we go to calculate the volume of the particles, the scenario changes completely.

Here we must introduce some simplifying hypotheses. Let's imagine that all the particles are spheres and that their volume is given by the known formula:

$$V = \frac{4}{3} \pi r^3$$

Calculating the total volume of suspended solids we obtain this new graph:



It can be seen that, in this case, most of the volume of suspended solids in the water is between 20 and 160 µm, with 2 peaks at 50 and 150 µm.

The correct solution in this case could therefore be composed of 2, better 3, filtering steps with decreasing values (e.g. 100 - 50 - 5 µm).