Filtration Efficiency

Understanding retention efficiencies for filter cartridges

By: Chris Pasquali, CEO Factory Direct Pipeline Products, Inc.

Selecting the proper filter cartridge retention for a given application will reduce operating costs and ensure process specifications are achieved. Filter cartridge retention is expressed in microns (µm); 1 micron = 1/1000 (0.001) millimeters.

The retention is only part of the equation, it is the *efficiency* that is often overlooked or perhaps "assumed", thus contributing to insufficient or over-filtration.

Filter media used in the construction of filter cartridges are offered in two types of efficiencies, "nominal" and "absolute %".

"Nominal" Efficiency is manufacturer-defined efficiency and for our nominal rated filter cartridges, they are 70% efficient unless otherwise specified. Therefore, with a new (clean) filter cartridge, ≥70% of the particles of the stated retention will be retained by the filter cartridge. As particles become trapped within the filter cartridge media, the open area available decreases and thereby increases the efficiency of the filter cartridge.

As mentioned above, there is no "universal" retention efficiency required to be referred to as "nominal" – it is manufacturer defined and often not overtly stated; you will need to ask if your application is one of those sensitive to the initial retention efficiency.

Therefore, it is incorrect to assume that two different brands of "50 micron nominally rated filter cartridges" have the same efficiency; you will need to try each to determine which is the best value for your application. Generally speaking the more efficient the media is, the more costly it is because the manufacturers of the filter media can get top dollar for the more efficient portion of the media run.

In comparison to absolute rated filter media, nominal rated filter cartridges are relatively inexpensive and used for non-critical applications. They are also used as pre-filters to reduce the loading on the more expensive absolute efficiency cartridges.

"Absolute" Efficiency is much more intuitive and straightforward to understand. It refers to laboratory defined retention efficiency, often expressed with a Beta value or a Beta Ratio. Most of our filter cartridges have a Beta Ratio Chart expressing their efficiency based upon a stated particle size.

Example: our LOFPLEAT-HP 1.0 micron filter cartridges have a Beta 5000 or 99.98% retention efficiency for particles ≥ 1.0 micron. They can also be described as Beta 100 (99%) efficient for retention of particles ≥ 0.60 microns or Beta 50 (98%) efficient for retention of particles ≥ 0.30 microns.

Filter Removal Efficiency			
Beta Ratio Efficiency	Beta 5000 99.98%	Beta 100 99%	Beta 50 98%
0.2 µm	0.20	0.10	0.05
0.45 µm	0.45	0.30	0.20
1.0 µm	1.0	0.60	0.30
2.5 µm	2.5	2.0	1.5
5.0 µm	5.0	4.0	3.0
10 µm	10	8.0	7.0
20 µm	20	17	15

The Beta Ratio is established via laboratory testing and represents the number of particles up-steam of the cartridge divided by the number of particles downstream of that same cartridge for the targeted particle size.

$$\text{Beta Ratio} = \frac{\text{Upstream particle counts}}{\text{Downstream particle counts}}$$

Therefore, a Beta ratio of 5000 means that for every particle of a given size that bypasses the filter cartridge, there were 4999 that did not. The math follows:

Beta 5000 = 4999 particles retained from a total of 5000 ∴ 4999/5000 = 99.98% efficiency.

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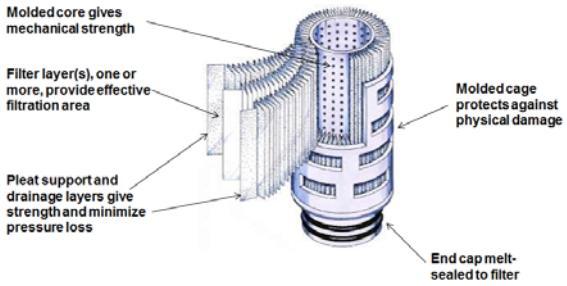
The testing methods used to determine efficiency can be complex and they are not to a universal standard; each manufacturer determines how they will test their efficiencies.

The testing method used for our Beta Ratios are based upon a "single-pass test method" using ambient water at a flow rate of 2.5 GPM for a 10" length cartridge. The types of particles used during testing are latex beads and special "coarse and fine test dust" (imagine that, "test dust"!). The removal efficiencies are determined using multiple laser particle counters which is the most sophisticated and effective method of counting dust particles.

Nuclepore 0.4µm Track-etch membrane with 0.5 µm latex beads

The actual efficiency for your application will differ due to operating conditions such as pressure fluctuations, differences in temperature and viscosity. This is another reason why trying different filter cartridge brands, media and designs can be beneficial to you, your process results will not likely correlate directly to "retention sizes or efficiencies" due to process variations anyway.

It is important not to confuse filtration efficiency with particle retention capacity; they are unrelated. The total volume of particles that can be retained within a cartridge and how the rate of increase in efficiency due to reduction of the open area available are not reflected in the Beta Ratio and testing. Underscoring once again that the physical design of the filter cartridge may offer capacity advantages even if the media used is the same across multiple brands/designs.



Our differential performance advantage compared to other brands is often based upon the manufacturing technology and design of the filter cartridge to provide higher volume of particle retention at relatively low differential pressures without sacrificing retention efficiency. The picture above illustrates a pleated design, although other advanced features can include a fixed pore structure that prevents particle unloading even under high differential pressures or a heavy molded "cage" to increase the overall integrity/strength of the filter cartridge.

Do you require nominal or absolute rated filter cartridges?

If you have sensitive applications requiring absolute rated media, you probably already know it and have an application that involves the food, beverage, pharmaceutical, cosmetics or petrochemical industries. It is important to note that the lesser expensive nominal rated cartridges can be used to extend the life of the much more expensive absolute rated cartridges, so the answer might be "both"!

We can provide you with free filter cartridges for testing and evaluation combined with free water test analysis/report, which will characterize the particle sizes and population within a given sample that you provide. The analysis eliminates "trial and error" for proper filter cartridge material and design. Why not take advantage of these free services today?

Chris Pasquali has been trained by Hayward Flow Control and Eaton Hydraulics Filtration Division, having provided sales and engineering support for these companies since 2001.