Beta Ratio vs. Efficiency

In fluid applications the particulate removal characteristics of a filter are stated by a pair of related terms. Those terms are the "Beta Ratio", B, and the "Efficiency", E.

The Beta Ratio is always stated at a particular Micron Rating,....as an example:

If a filter media is said to have a "Beta Ratio of 1000"...., this would be a meaningless description !
The Micron Rating must also be referenced.
To state that this filter media has a "Beta Ratio of 1000 @ 15 microns" now makes sense.

Here's why:

The media specification of "Beta Ratio of 1000 @ 15 microns" means that for every 1000 particles of size 15 microns or larger that challenge, or approach, the media only 1 will pass through. This of course means that 999 will be stopped,....translating to a removal efficiency of 99.9%.

In this particular instance the Beta Ratio offers no specification on what happens to particles that are smaller than 15 microns. For this reason most media specifications have Beta Ratios referenced at numerous micron ratings.

In one particular application the media was specified as follows:

Media Rating of: **a) 99.50% efficient @ 15 micron (B=200)**
b) 98.00% efficient @ 7 micron (B=50)
c) nominal efficiency @ 1 micron

This means that for every 200 particles, 15 microns or larger, that challenge the media;
1 will get through and 199 will be stopped.
AND.....
for every 50 particles, 7 microns or larger, that challenge the media;
1 will get through and 49 will be stopped.

The Nominal efficiency rating can vary widely from manufacturer to manufacturer.
Efficiencies from 30% to 80% can carry the tag "Nominal" depending on which manufacturer you are looking at. That is why the **Beta Ratio** is the most quantifiable and reliable specification.

In actuality, the filter media will capture particles over a wide range of microns, even down to 1 micron or below. In fact as a filter media traps more and more particles those particles themselves act as a barrier to other particles approaching the media with the result of smaller and smaller particles being stopped. This added benefit of increased efficiency, by leaving filters in line too long, however, has an offsetting cost. That cost is rapidly rising differential pressure and reduced flow.

Here is the math.....

Let "U" = the number of Upstream particles headed toward a filter
Let "C" = the number of particles Caught by the filter

Then the "Beta Ratio" term is defined as follows:

$$B = \frac{(\text{\# of Upstream particles headed toward a filter})}{(\text{\# of Downstream particles that got through the filter})}$$

$$B = \frac{(\text{\# of Upstream particles headed toward a filter})}{(\text{\# of Upstream particles headed toward a filter}) - (\text{\# of particles Caught by the filter})}$$

$$B = \frac{U}{U - C}$$

$$B = \frac{1}{1 - (C/U)}$$

The "Efficiency" term is defined as follows:

$$E = \frac{(\text{\# of particles Caught by the filter})}{(\text{\# of Upstream particles headed toward a filter})}$$

$$E = \frac{C}{U}$$

Also by rearranging terms we get:

$$B = \frac{1}{1 - E}$$

and

$$E = \frac{B - 1}{B}$$

It can easily be seen that as the "Beta Ratio" increases so does the Efficiency and vice-versa.

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