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COMPARING FILTER PERFORMANCE

The most commonly used filter rating is the Beta ratio (ß) which is defined as the number of particles upstream of the filter divided by the number of particles downstream. A ß rating always pertains to a specific particle size and larger. For example, a filter designed to remove 3-micron particles and passing a ß 75 test rating will have on average 75 particles equal to or larger than 3 microns upstream of the filter for every one particle equal to or larger than 3 microns downstream of the filter.

Filter efficiency can be calculated directly in one of two ways:

- Filter test results: (# of downstream particles)/(# of upstream particles) x 100
- From ß as follows: (ß-1)/ß x 100.

For example, a ß 75, 3-micron filter is 98.67% efficient at removing 3-micron and larger particles as calculated by either method: (74 particles removed)/(75 upstream particles) x 100 = 98.67% or (ß 75-1)/(75) x 100 = 98.67%.

A ß 200, 3-micron filter is 99.50% efficient at removing 3-micron and larger particles. Although this filter increases efficiency by “only” 0.93% over a ß 75 filter, a ß 200 filter removes 199 particles for ever particle that passes through the filter, compared to a ß 75 filter that removes only 74 particles for every particle that passes through the filter, and that is an immense difference when considering the concentration of contaminants in the fluid that must be filtered. For example, were a ß 200 and ß 75 each going to filter a hypothetical gallon of fluid down to the same level of purity, the ß 200 filter would be able to start with a fluid whose contamination is *three times greater* than the fluid being cleaned by the ß 75 filter.

The ISO (International Organization for Standardization) standard for ß testing filters was 4572 and then replaced in 1999 by ISO 16889 for multi-pass ß testing. The ISO 16889 multi-pass ß testing provides the same common testing format with particle counters and other test equipment that provide greater measurement precision than those used in pre-1999 ISO 4572 tests.

Under the old standard, ratings are marked ßx=y (e.g. ß3 = 200) where *x* stands for the particle size for which the rating is valid, and *y* represents the rating itself. The new standard adds the subscript (c) (e.g. ß7(c) = 1000) to differentiate current ISO 16889 multi-pass tests results from pre-1999 ISO 4572 tests results.

Particle size standards in microns used in filter test fluids are as follows:

- ISO 4572: <1, 3, 6, 12, 25
- ISO 16889: 2.5, 5, 7, 12, 22

The two standards define the micron sizes differently:

- ISO 4572: particles are "ball milled" with the identifying micron size of irregularly-shaped particles based on the longest dimension.
- ISO 16889: particles are "jet milled" with the identifying micron spherical diameters based on irregularly-shaped particles' equivalent spherical area.

A benefit of the ISO 16889 multi-pass standard is having available various specified ß across a wide size range; such as, 2.5, 5, 7, 12 and 22 microns; showing how a filter performs over this specified range of particle sizes comparing performances to the same required ß of other selected filter elements.

ß	Filter Efficiency
2	50.00%
10	90.00%
75	98.70%
100	99.00%
200	99.50%
1000	99.90%

Standardization gives a reliable comparison among different published ß, rather than relying on only ß selected by filter element manufacturers. ISO does not perform the product testing and does not specify filter performance requirements, but it does issue test procedures, such as those requiring filter manufacturers to determine average particle sizes yielding ß equal to 2, 10, 75, 100, 200, and 1000, that is, standardizing filter testing so that results are comparable. If published ratings for filter elements P and R are ß6.3(c)>200 and ß5.7(c)>200 respectively, comparison shows little difference. However, if filter element P tested ß7.8(c)>1000 and filter element R could not reach a ß(c)>1000 test result within the ISO 16889 particle size range, filter element selection would be simplified.

Multi-pass tests are performed in steady-state, laboratory conditions, which do not contain actual operating conditions, such as, pressure surges, flow rate changes and temperature variations. These differences in fluid thermodynamics can affect filter performance. ß tests also do not indicate dirt holding capacity, total amount of material trapped during a filter's life, nor changes over time in capture efficiency. Nevertheless, multi-ßs calculated over a range of particle sizes are the best available method to gauge expected filter performance.

Filters control particles in fluids to contaminant compositions permitting required system performance, life and reliability that allow fluid to flow through process equipment at minimum pressure drop, thereby minimizing stress and energy losses as well as protecting components from particles large enough to damage, penetrate, and interfere with moving equipment clearances. Failure to provide necessary control of damaging-sized particles will lead to a substantial increase in the number of particles generated within the system through a chain reaction of wear. Particles entering moving equipment clearances typically become work-hardened and produce more wear particles, making filter particle capture necessary to maintain a healthy system. Regular monitoring of fluid cleanliness using ISO particle counting should be used to determine critical filter efficiencies in actual field conditions and correlating results with equipment maintenance history.