Pall Corporation

Scientific & Technical Report

The Cyclic Stabilization Test

Measuring Realistic Filter Performance

How Good is Your Filter?

- How well does it protect your system?
- Does your filter's performance change during its service life?

Understanding what a filter can and cannot do is essential for providing the best protection for systems and system components. This document describes current filter performance measurement practices and a new method that provides an improved, more practical measure of filter performance.

How is Filter Performance Measured?

Evaluating filters in an actual operating system is the only sure way to establish that a filter will perform to expectations as well as achieve and then maintain the required fluid cleanliness level throughout the filter's service life. However, it is often impractical to perform such tests, for reasons of time and consistency.

Filter selection and comparisons are usually made primarily on the basis of the filtration (Beta) ratio and dirt holding capacity determined by Multi-pass testing. However, there are many other parameters vital to maintaining filter element integrity and desired performance in actual operation, including the strength and stability of the filtration medium, the filter's ability to withstand flow and pressure surges, as well as those conditions induced by cold start-ups.

Using Multi-pass performance as the sole filter specification is inadequate, as often weaknesses or deficiencies in performance are overlooked or not exposed because of limitations in the scope of testing.

Impact Of Variable (Cyclic) Flow

A survey of hydraulic equipment manufacturers revealed that nearly all filter installations are subjected to some type of variable (cyclic) flow. In addition, numerous studies have been conducted relative to the impact of unsteady flow on filter performance. Generally, *the results indicate that the filtration (Beta) ratio was found to decrease as a function of increasing cycle rate.*

Impact Of Reduced Or No Contaminant Ingression

The contaminant ingression rates during the ISO 16889 Multi-pass test are 1,000 to 10,000 times higher than the average ingression in actual service. This high ingression rate tends to overshadow performance degradation and particle unloading. When clean-up tests are conducted on a previously contaminated system with no ingression, the performance of the filter, measured in terms of efficiency, generally degrades as the system becomes cleaner. In fact, *the system contamination level stabilizes at some measurable level and does not go to zero.*

*Filtration. Separation. Solution.*SM

This is one of the primary flaws in the interpretation of the basic Multi-pass test, where the filtration ratio is assumed to be roughly constant. In reality, when the system contamination level stabilizes, the Beta ratio approaches a value of one (zero efficiency) and the upstream level is roughly equal to the downstream level. For a system clean-up test with constant flow, *the stabilization level is related to the quality of the filter and the degree of particle unloading.*

A New Approach: The Cyclic Stabilization Test

In order to address the deficiencies in the Multi-pass test, Pall Corporation has developed the Cyclic Stabilization Test, which provides a more realistic measurement of filter performance. This laboratory test examines a number of areas of operation: steady state performance, cyclic flow performance, and the effects of contaminant loading on the retention and unloading characteristics of the filter.

During the test procedure, clean up and stabilized particle count levels are measured for both steady and cyclic flow conditions at different stages of the filter's life.

A great deal of information can be gathered from a Cyclic Stabilization Test. This includes:

- Measurement of the initial steady flow filtration (Beta) ratio.
- Measurement of the initial cyclic flow filtration (Beta) ratio.
- Initial clean-up and stabilization measurement (with the filter in a clean condition) – both with steady and cyclic flow.
- A measurement of cyclic flow filtration (Beta) ratio throughout the remainder of the test
- Clean-up and stabilization measurement as the filter is loaded.
- Clean-up and stabilization measurement at 80% of net* pressure drop (with the filter in a nearly completely loaded condition).
- A measurement of retained dirt capacity under cyclic flow conditions.

Figure 1 shows the upstream particle counts greater than 5 µm(c) obtained while conducting a Cyclic Stabilization Test on a test filter. At each step the initial particle concentration is very similar, but *cleanup is reduced with the introduction of cyclic flow, and further reduced as the filter becomes more plugged.*

The stabilized contamination level at 2.5% net pressure drop is 11 times that of the steady flow value. At 80% net pressure drop the stabilized contamination level is 1,200 times that of the new filter steady flow value. These increases are indicative of the inability of the filter to retain contaminant under these conditions.

* net pressure drop equals terminal pressure drop minus clean pressure drop.

Figure 1 Cyclic StabilizationTest - Upstream Particle Counts >5 µm(c)

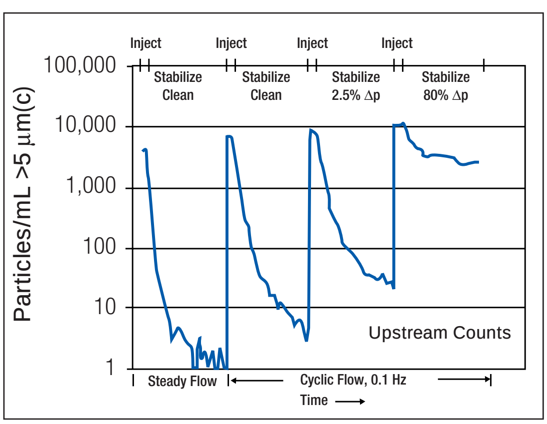

Figure 2 Cyclic Stabilization Test - Downstream Particle Counts >5 µm(c)

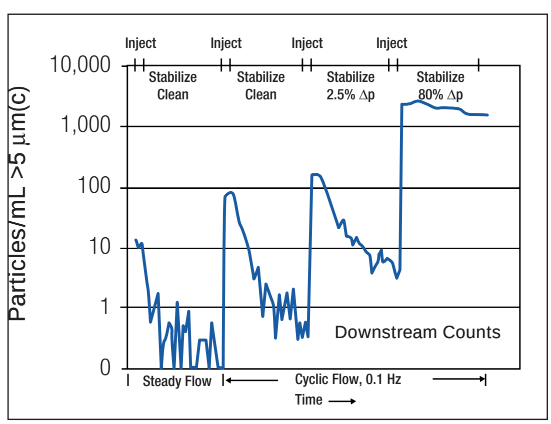

Figure 2 shows downstream contamination data for the same test filter. Here, stabilized counts increase substantially during flow cycling and filter loading. *The data represents a final Beta ratio at 5 µm(c) of 1.8 compared to the initial steady state Beta ratio of 310.*

The Cyclic Stabilization Test: A Better Method to Compare Filter Performance

The Cyclic Stabilization Test provides a much clearer picture of a filter's performance throughout its life in a fluid system.

In order to demonstrate the ability of the Cyclic Stabilization Test to discriminate between similarly rated filters, tests were conducted on filters from Pall and several other manufacturers.

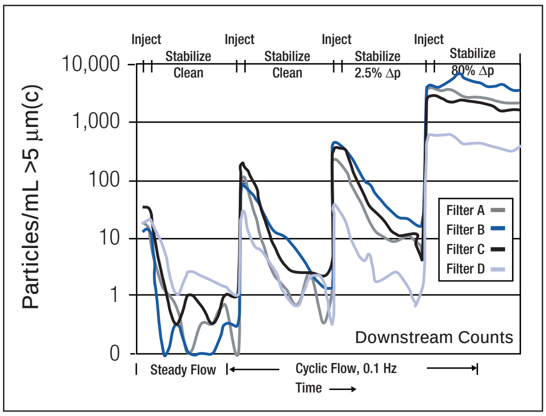

Figure 3
Downstream Results From Four Similarly Rated (Multi-pass) Filters

Figure 3 shows the 5 µm(c) downstream particle counts for these filters. These tests demonstrate that although the filters provide good control of particles >5 µm(c) when new or with steady flow, their ability to control particles changes substantially when they become loaded and are under cyclic conditions. For example, Filter "B", which was one of the best performers under steady flow, exhibited the worst particle control under cyclic and loaded conditions.

When comparing filter performance, one should focus on the stabilization data at 80% of terminal pressure drop. This is where the greatest performance drop-off occurs, and the point in the filter's life where your system can be most at risk.

Rating a Filter in Terms of Fluid Cleanliness

Ideally, filter performance ratings should closely depict how a filter performs in actual service. The Cyclic Stabilization Test most closely represents field operation by determining the stabilized fluid cleanliness level that a filter maintains under cyclic and dirt loading conditions. The results are reported as an ISO 4406 cleanliness code giving the user a recognizable performance measurement.

The ISO 4406 Cleanliness Code is based on the number of particles greater than 4, 6, and 14 µm(c) per milliliter of fluid. Actual particle counts based on the stabilized downstream level at 80% net pessure drop are shown for filters in Table 1.

Table 1
Downstream Cleanliness for Filters Tested

Filter	>4 µm(c)	>6 µm(c)	>14 µm(c)	ISO Code
A	4,200	540	20*	19/16/<11
B	7,200	970	47*	20/17/<13
C	3,400	420	18*	19/16/<11
D	1,100	70	0.8*	17/13/<07

Based on these results, it is clear that filter "D" maintains the best fluid cleanliness, and therefore will provide the greatest protection to the system. This represents a clear differentiation in filters with similar multi-pass ratings.

* Actual count performed for particles >10 µm

Pall Corporation has developed a new line of filter elements that incorporate media designed to provide superior protection for critical applications. These elements achieve low stabilized fluid cleanliness levels throughout their life without sacrificing service life. Shown in Table 2 are the Cyclic Stabilization Test 80% pressure drop¬ ratings for Pall SRT media grades. These values are based on a flow cycling rate of 6 cycles/minute with flow varying from 25% to 100% of rated flow.

Table 2 Pall SRT Filter ISO Code Ratings from the Cyclic Stabilization Test

Pall SRT Media Grade	ISO CODE Rating per Cyclic Stabilization Test (80% pressure drop)*
AP	12/07/02
AN	15/11/04
AS	16/13/04

* based on 4 bar (60 psid) terminal pressure drop

Conclusions

Conditions such as varying flow, cold starts, shock, and vibration can potentially reduce the effectiveness of a filter in an operating system. This may cause the filter to release previously held contaminant, and consequently make it less effective at removing the critically sized particles.

The data from an ISO Multi-pass test is often used by procurement agencies as the key performance factor in the process of selecting filters, and sometimes as the sole criterion. This test has the potential to exaggerate a filter's capabilities.

The Cyclic Stabilization Test examines the effects of cyclic flow conditions and contaminant loading on the capture and retention characteristics of the filter. The result is an improved filter performance reporting method that provides a much more realistic measure of how a filter performs in actual service and gives the user (via ISO Codes) a closer representation of the level of contamination control that can be maintained throughout the filter's service life.

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