The "DNA" of your Filter and Filter Media

By Gerard J. Lynch, P.E. and Matthew Borsinger, IFTS Inc. USA

When used in solid-liquid and liquid-, liquid separation applications filters serve a critical function to ensure process quality and repeatability. Whether removing particulates that can damage equipment or removing water from fuel to extend system service life, improper filter design and selection can result in catastrophic failure.

Figure 1: Before and after a collapse test

The concept that filters have a specific "DNA" may seem odd but just as Deoxyribonucleic Acid ("DNA") defines the nature of the human body, there is a "DNA" associated with a filter that defines how it will perform. Filters are used to separate many different particles and liquids. The effectiveness and efficiency of filters can be determined by laboratory testing before expensive plant modifications are made for real world use. For instance, most filters and filter media have an "unloading point" that is a measureable differential pressure at which filters release trapped contaminants downstream. The correct testing can find these "unloading points". These released downstream particulates can erode or ruin an engine, cause scrap in food and beverage processing, or may even seize mechanical system components. Even an area before the burst point where the particulates down stream increase, due to change in pressure or other external conditions, can still destroy the system. Each filter has its own attributes and to determine them you need to consider multiple tests to define the "DNA" of a filter.

The testing to determine the "DNA" of a filter is much more inclusive than simple initial efficiency, mean pore flow or bubble point testing techniques. While these provide a good starting point, "DNA" testing is more holistic than the above-mentioned tests that provide only one small detail about the filter. The idea of knowing more about a filter is essential in determining where the filter would perform the best and where it will perform the worst. "DNA" tests using international standards provide results that are repeatable and allow "apple to apple" comparison with other filters and their applications.

The "DNA" of a filter is formed from the results of various tests depending on the process application.

The tests that help form the "DNA" of the filter include:

- Burst or Collapse Point Test
- Initial Differential Pressure Test
- Efficiency Over Time Test
- Dirt Holding Capacity Test
- Porosity Test
- Wettability and Contact Angle Test
- Bubble Point and Fabrication Integrity Test
- Roughness Test
- Mean Pore Flow Test
- Water Separation Efficiency Test

With the results of these tests the characteristics of the filter will come to light.

CONTRIBUTING FACTORS

Burst or Collapse Point (ASTM D3786, ISO 4020, ISO 2941, SAE J80)

Filters maintain the cleanliness of fluid in a fluid power system by removing insoluble contaminants. A filter element is the porous device that performs the actual process of filtration.

The capability of the filter element to maintain a specified fluid cleanliness level depends on its performance and structural integrity, and its ability to withstand non-steady-state conditions (e.g., cold starts and decompression surges). The filter element's resistance to collapse or burst is a measure of its ability to withstand such effects.

The burst or collapse point test uses a device that injects fluid into the system either continuously or intermittently (sometimes known as "batch loading"). The fluid has a controlled amount of test contaminant that does not exceed 5 % of the element's estimated contaminant capacity, at intervals of at least 2 minutes, while maintaining the specified test flow rate and test temperature. The contaminant used is injected in a uniform manner and at low enough concentration so that the pressure measurement equipment can detect any structural failure.

Flow rate and differential pressure are measured across the filter as a function of contaminant mass added (by mass or time) until the differential pressure across the element (filter assembly differential pressure minus housing differential pressure) meets or exceeds the specified collapse or burst pressure rating or until failure.

The filter element collapse or burst pressure rating is verified if:

a) There is no visual evidence of failure in the element's structure, filter medium and seals, when tested, i.e. as described in ISO 2942

b) There is no abrupt decrease in the slope of the differential pressure versus contaminant mass added curve prior to the specified collapse/burst pressure rating.

Initial Differential Pressure

This test deals with a simple differential pressure across the filter as the system is running. This test does not give much information about the filter's performance over time but is a standard test, which can give information useful in designing a system. The Initial Differential Pressure test defines a baseline against which to gauge other tests and applications.

Efficiency Over Time

The efficiency over time test tells you how well the filter removes particulates over a set period of time. This test is usually done with a continuous or batch amount of particulate added to the stream at even intervals and a particle counter downstream to determine how many particulates make it through the filter.

Porosity

Porosity tells how many holes are in a filter media sheet. This test can tell you how much void area there is on a single sheet of a filter media. This is a standard test for all filters.

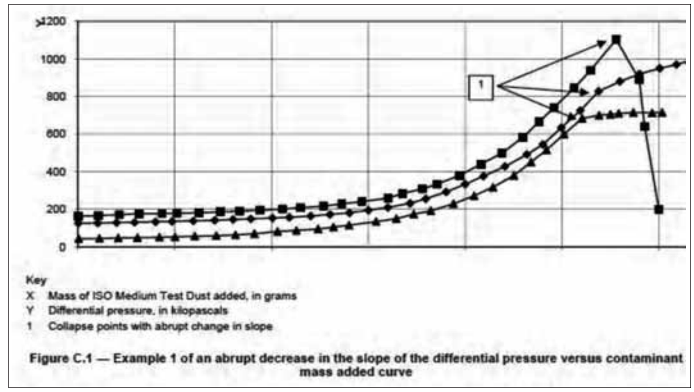

Figure 2: Abrupt decrease in the slope of the differential pressure vs. contaminant mass added curve indicated contaminant release and possible structural failure

Wettability

The wettability of a filter determines how the filter interacts with the liquid. Wetting is the ability of a filter to reduce the surface tension of the liquid with which it is in contact. This information will make it easier to understand the differential pressures and how the filter interacts with specific liquids.

Bubble Point, Fabrication Ingtegrity Test

(ASTM F316, ISO 2942, ISO 4020, JIS K 3832, SAE ARP 901)

The International Standard specifies that a bubble-point test method is acceptable to measure for filter elements used in fluid power systems. It can be used either to verify the fabrication integrity of a filter element (by checking the absence of bubbles) or permit the localization of the largest pore of the filter medium by determining the first bubble point. The pressure at which the first bubble point occurs at is re-

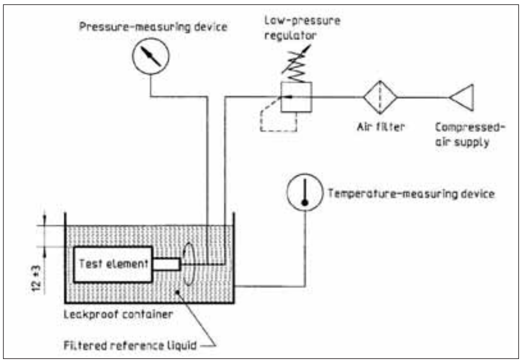

Figure 3: Typical bubble-point testing apparatus

lated to the largest pore size. It, therefore, defines the acceptability of the filter elements for further use or testing.

This test is best performed under controlled conditions in a laboratory to ensure that it is done correctly. The results also have little to no meaning if they are not done by a certified lab because the standards are specific to a process that is done with many checks and balances. Extra air bubbles that come from the pipes or just a valve that is not sealed well can ruin this test. Results need to be certified by a registered and accredited lab in order to insure the methods used comply with industry standards.

Roughness

A measurement of the filter media surface roughness is used to determine how the liquid will run over the surface of the filter media. The roughness can tell you more about how the differential pressure will change due to frictional forces and also the efficiency because of the ability of the filter to catch particles.

Permeability

The permeability test determines the ability of a liquid to move through a filter. The test will determine how well the liquid moves through the filter and in what time period it is able to move through the filter under constant conditions.

Water Separation Efficiency Test

(ISO 16332, SAE J 1488..)

Modern fuel injection systems, installed in passenger cars as well as in heavy duty or off-road vehicle applications, require high and stable separation efficiencies for all insoluble contaminants in the fuel to ensure a prolonged service life. Beside solid contamination, undissolved water, in finely or coarsely emulsified form, can also reduce the lifetime of injection systems. Suitable fuel filters, having a high level of water separation efficiency, are an absolute necessity for system longevity, especially with Bio-fuels.

Factors found to affect the separation efficiency of undissolved water in the field include:

- The fuel quality, which is strongly influenced by the performance of additives in the fuel itself

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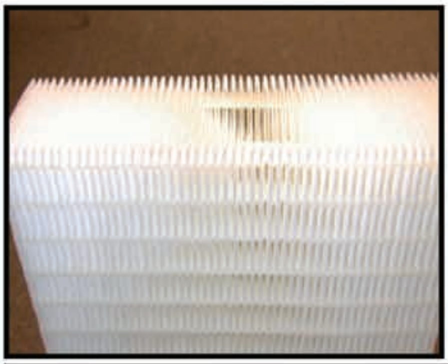

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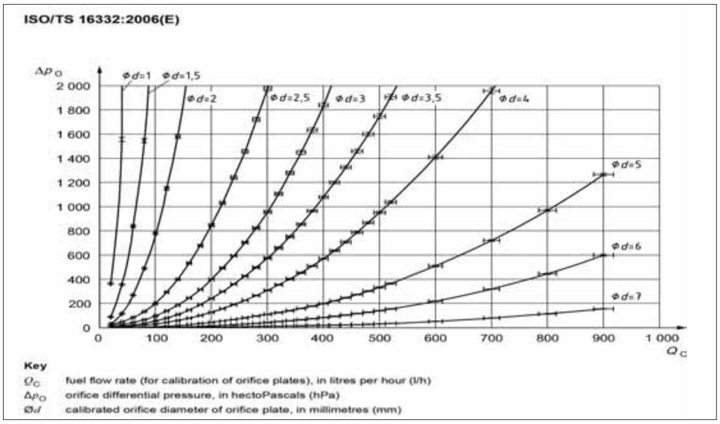

Figure 4: Diameter of emulsification device

- The actual characteristics of the fuel/water-emulsion
- The specific flow rate of the system
- The type of media in the filter element
- The size and design of the filter housing itself

Different fuels and additives can be used to test the filter. To ensure laboratory test results are comparable, these various parameters have to be taken into account in the test method in order to reduce their influence on the test results. The optimal droplet size has to be determined by testing using proper measuring sensors. In the ISO standard different orifice plates/sizes are used to produce consistent water test droplets.

CONCLUSIONS

Only a few tests have been summarized above and there are many more that can provide essential information about a filter or filter media. There are also tests that are specific to the industry, application and fluid in which the filter will be used. Knowing the "DNA" of a filter helps you determine all areas that will affect filter performance in the intended application. A client with a filter media who doesn't know the best environment will benefit from filter testing and this can help determine possible target applications. The laboratory tests performed on filters have excellent reproducibility and can be used to compare and benchmark filter performance anywhere in the world. FN

Gerard J. Lynch, P.E. and Matthew Borsinger are with International Filtration Services Inc., (IFTS Inc. USA) in Springfield, New Jersey. Jerry Lynch serves as President and Matt Borsinger as a Chemical Engineering intern. IFTS is an independently regulated laboratory and research center for liquid filtration and separation science. IFTS has locations in Europe, USA and China, providing filtration testing and research services to many industries. The management at IFTS has compiled a world class team of scientists, engineers and technicians in the field of Solid-Liquid Separation. IFTS provides a global resource for professionals working in Solid-Liquid Separation (SLS).