Automotive Filter Selection

By: Andy Coverdell, Noria Corporation

Synopsis: There are numerous choices when it comes to selecting an automotive oil filter. To gain a true understanding of filters on the market, they must be compared on a level playing field. To level the playing field two main areas are reviewed: ISO 4548-12 and overall construction. Once the oil filters are accurately compared one can select the correct filter for the application. Various performance parameters and end user goals must be weighed to determine the best filter at the right price.

Introduction

Whether you drive a top-of-the-market luxury car or an old farm truck, automotive filtration is important to your vehicle. In a study performed by General Motors, they reported that "compared to a 40-micron filter, engine wear was reduced by 50 percent with 30-micron filtration. Likewise, wear was reduced by 70 percent with 15-micron filtration."

History of Automotive Filtration

During the first half of the automotive industry, it was common practice to not even use filtration on the motor oil. Only strainers and screens were used for catching large objects. For the conditions this was acceptable practice. Motor oil was cheap and frequently changed and the life expectancy of vehicles low. With frequent oil changes a reasonable life was obtained from the vehicles.

The first form of motor oil filtration introduced was bypass filtration. This allowed the lubricant to be filtered without affecting the oil flow to the engine. These filters included built-in sight glasses that could be used to determine if the filter was plugged. A bypass setup filters about 10% of the lubricant, allowing 90% of the oil to reach the oil gallery unfiltered.

Starting in the 1950s some vehicles were designed with full flow filters. It ensured that all of the lubricant was filtered before it entered the main gallery. From this introduction, oil filters have evolved from cartridge filters to the modern disposable filters that are used today. Over the past 50 years the filter media has also undergone change and modifications to enhance the overall performance of the oil filter.

Some automotive enthusiasts move beyond the standard and employ both bypass and full-flow filtration. This combination is more predominant in the trucking industry, but it is employed on a few passenger vehicles. The full-flow filter does the bulk cleaning of the lubricant while the bypass filter polishes the motor oil by removing the finer particles.

Contamination Control

The objective of every automotive filter is contamination control. Wear debris, dirt, soot and any other material that can enter the lubricant will propagate throughout the engine accelerating the wear and, in worst case situations, plug crucial passages resulting in oil starvation. These contaminants are constantly being ingested into the engine; therefore an appropriate filter should be selected.

Terrain dust is considered the most harmful contaminant. A large portion of the Earth's crust is silica and silicates. In addition alumina is also prevalent. Both silica and alumina are harder than a hack saw blade. Most lubricated surfaces in an engine are softer than a hacksaw blade.

The first line of defense against airborne contaminants is the air filter. It is easier to remove the contaminants before they enter the oil than after. Many high performance air filters have a low capture efficiency to improve the flow, but at what cost to engine wear? Owners using high flow filters need to ensure the capture efficiency is aligned with the expectation of the engine life.

It has been shown by studies that particles between 2 and 20 microns are the most damaging. This is due in large part, to the fact that this is also the typical oil film thicknesses in an engine. If a particle is smaller than the film thickness, letss say 2 microns or smaller, it will pass through the lubrication zone with minimal contact to the surface. On the other hand, particles considerably greater than the film thickness, particles large than 20 microns, will typically go around the lubrication zone. Particles that exist in this 2 to 20 micron range are the most dangerous. They will enter the lubrication zone disrupting the lubricant film surface resulting in abrasive wear. A filter should be designed to capture these harmful contaminants.

Filter Design and Composition

Oil filters have many components all of which need to perform their function to ensure proper filtration. The typical filter is located after the oil pump. The filter is enclosed inside of a canister attached to the filter block. The following is a review of the components that are in a typical oil filter.

Exterior Canister

The canister is a vital part of the filter assembly. Observe the wall thickness and ensure that it is rigid enough to protect the element. Inside, it is exposed to the pressure generated by the oil pump. The oil filter must provide sufficient strength to eliminate the possibility of bursting when the pressure spikes. If the filter is located on the underside of the vehicle it may be exposed to road debris, which could puncture the wall. During installation and removal the canister is also placed under stress. The wall needs to be strong enough to be installed and removed without collapsing or cracking.

Filter Media and side seam

Observation of the oil filter media can provide good insight into the general quality. The filter is generally composed of cellulose, synthetic glass fibers, or a combination of the two. The media is pleated to maximize the surface area. One problem that can occur is pleats sticking together. A good filter should have the pleats evenly spaced.

Observe the side seam of the filter, were the ends of the pleats are joined. There should be no openings or tears. If there are any openings unfiltered lubricant will pass through the seam. Seams are typically joined with staples, glue or both.

End Caps

The end caps are glue to the media holding the pleats in place. Ensure that the media is securely glued to the end caps and that there are no gaps at the joints. Glue can also wick up into the filter media, reducing the effective surface area of the media.

Center Tube

The center tube is the backbone of the filter media. It prevents the media from collapsing, especially during cold starts or conditions when a high pressure differential is developed. Evaluate the tube for strength and ability to function as a rigid support.

Spring

A spring is used to ensure that the upper end cap of the element is firmly pressed against the base plate of the canister providing a good seal. The spring is normally located in the bottom of the oil filter, applying pressure to the element.

Anti-drainback valve

Most automotive oil filters have an anti-drainback valve. It prevents the motor oil from draining out of the filter and back into the sump. This prevents contaminants from being backwashed, and it reduces momentary starvation when the engine starts. The most common design is a flapper behind the base plate. Typically the flapper is either silicone or nitrile, but silicone provides a more flexible material for cold temperature applications. Inspect the flapper ensuring that it is flexible and provides a good seal with the base plate.

Bypass valve

It is common for a bypass valve to be built into the oil filter element. Observe whether the seat is soft or hard. A soft seat employs the use of an elastomer, whereas a hard seat is metal-on-metal contact. The hard seat may leak allowing unfiltered lubricant to go around the media. Even with the soft seat ensure that the elastomer is soft enough to provide a good seal.

Filter Performance

When selecting motor oil, there are numerous standards and certifications that can be referenced to select the proper lubricant. In fact, API provides a certification program for lubricants to meet. The API donut, which is clearly printed on all certified lubricants, will indicate which vehicle the lubricant has been approved for. When it comes to selecting an oil filter, it is all in the marketing.

If you go to your local automotive store and try to select an oil filter based on its performance, you will get nowhere fast. Almost every filter on the shelf claims that they are the best. For example, some common phrases are, "Our filter is 98% efficient," or, "We are nominally rated at 10 microns." Both of these examples only provide half of the information you need. Every filter will be 98% efficient at some micron level. 20, 30, 40…your guess is good as mine. The second example uses nominal – what is nominal? From the documentation that I have reviewed it can be anything above 50% up to 98%. This is a pretty wide range.

Performance Standards

For the determined few that want to obtain the best filtration, you might even start calling the filter companies. A few are open and willing to share their performance results, but the rest always provide one common answer: "That is proprietary information." These are simply performance values that can be obtained by anyone who has the proper testing equipment.

There are two main performance standards – SAE HS 806 single pass and ISO 4548-12 multi-pass. Both of these tests are commonly performed on automotive filters to determine their performance.

SAE HS 806

The SAE HS 806 was created in the 1950s and uses a gravimetric method to determine the amount of contaminants captured by the filter. The following is an example of some of the performance parameters obtained.

- Resistance to Flow
- Filter Capacity and Containment Removal Characteristics of Full-Flow Filters
- Single Pass Particle Retention Capability Test
- Media Migration Test
- Collapse Test for Lube Oil Elements
- Inlet and Outlet Anti-Drain Valve Test
- Ability to Meet Environmental Conditions
- Installation and Removal
- Mechanical Tests
- Relief Valve Performance

ISO 4548-12

The multi-pass test ISO 4548-12 has superseded SAE J1858. Both tests were similar, so SAE canceled SAE J1858. This performance test provides three crucial values: beta ratio, dirt-holding capacity, and pressure-flow profile.

In comparison to SAE HS806, ISO 4548-12 uses an automatic particle counter upstream and downstream of the filter during the test. The particle counter provides the quantity and size distribution of particles being captured by the filter. The test provides the dirt-holding capacity by running the procedure until the filter plugs.

The beta ratio is nomenclature used to indicate the capture efficiency of a filter obtained by ISO 4548-12 or SAE J1858. To accurately indicate the capture efficiency, the number of particles filtered out at a specific micron size must be known. Figure 1 below provides information on determining the beta ratio and the capture efficiency.

The dirt-holding capacity provides an estimate of the expected life of the filter. This performance value is just as critical as the capture efficiency. Without sufficient holding capacity the filter will plug up and go into bypass. Several factors should be considered when comparing the dirt-holding capacity:

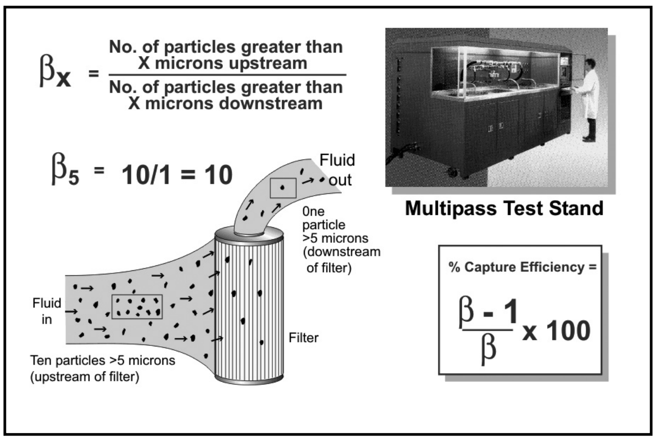

Figure 1: Beta Ratio and Capture Efficiency

- **Dusty/Dirty Environment:** Operating a vehicle on dirt roads or in other dusty environments increases the amount of contaminants that your oil filter needs to hold.
- **Extended Drain Interval:** If the filter is not changed during the extended drain interval it will need to have a high dirt-holding capacity to accommodate the extended interval.
- **High Capture Efficiency Filter:** In theory the more contaminants captured the faster the filter will plug. This is one of the common fears that keeps the industry from increasing the capture efficiency, but some high capture efficiency filters are designed with a high dirt-holding capacity.

The dirt-holding capacity is commonly the condemning factor that determines the useful life of the filter. Unlike many large diesel engines, automobiles provide no method for determining whether the filter is in bypass. Because of this automotive oil filter change intervals are largely guess work.

High Performance Filters

Do you need a premium oil filter on your vehicle? As with synthetic motor oil the premium product and the associated price shouldn't be applied to every application. Some vehicles just won't experience the conditions that need the extra protection from a high capture efficiency filter. It is often stated that the higher the price the better the oil filter; as this is generally true it is not always true. For example, high performance racing filters will have a poor capture efficiency to increase the flow rate and decrease the pressure drop. The following is a list of conditions where a premium filter would be needed.

High-Performance Engines

For high end sport cars and high end SUVs where performance and reliability are expected form the engine it is reasonable to pay for the premium filter.

Luxury Car Engines

This is a typical example of when the vehicle is so expensive that only premium products should be used.

Extreme Cold Starts

Cold temperatures place extreme conditions on oil filters. As cold lubricant is forced through the filter it needs to respond correctly to prevent the center tube from collapsing. A premium filter will likely have a strong center tube and a more responsive bypass valve.

Extended Drains

Even when high quality synthetic lubricants are used, the rate at which contaminants ingress into the oil will remain the same. It should also be noted that since the oil is in service longer it will build up more fine contaminants that pass through the filter.

Towing and Heavy Loads

A vehicle that is commonly used for towing or hauling heavy loads stresses the engine. As more stress is placed on the engine the film thickness is reduced which increases the wear. A premium filter will ensure that the lubricant is clean reducing the accumulation of wear particles. In this situation it is important to have both high capture efficiency at a low micron level and high dirt-holding capacity.

Long Engine Life

To achieve long engine life a premium filter is needed. Increasing the capture efficiency of the filter will reduce the wear in the engine extending the life. The table below illustrates the expected life using certain capture efficiencies.

Miles to First Overhaul	Required Micron Rating at Beta (X) > 75 (98.7% capture efficiency)
150,000	45 microns (standard economy filter)
200,000	30 microns
250,000	20 microns
400,000	10 microns (high-capture efficiency)

Table 1: Effects of Capture Efficiency on Engine Life

Low Viscosity

Some manufacturers are recommending lower viscosity grade oils, such as 5W-20. With these thinner viscosities comes thinner film thickness in the lubricating zone. This increases the need for high capture efficiency oil filters that will remove the smaller contaminants and wear particles.

Summary

Both the filter components and the performance tests should be used to accurately compare oil filters. For now the performance values are hard to obtain and sometimes impossible, but this should change over time. The values that are shared by the filter manufacturer are often distorted and misleading. This leaves evaluating the components that compose the oil filter assembly. These evaluations will provide insight into the overall expected performance.

References:

Fitch, Jim C. “Selecting the Second Most Important Lubrication Component – The Oil Filter.” Chapter 9, How to Select a Motor Oil and Filter for Your Car or Truck. 2nd ed. Tulsa: Noria, 2003

Phil Ramsey, "Coming Clean with Filters." Machinery Lubrication Magazine. November 2004

Staley, David R. “Correlating Lube Oil Filtration Efficiencies with Engine Wear.” Presented at 1988 SAE Truck and Bus Meeting and Exposition (SAE Paper 881825).