A Preliminary Study of Branded Lubrication Filters: Filtration Efficiency Comparisons

1 Background

This started, like many of my "white papers", as a thought experiment. In this case, the thought experiment was "Is there a data-driven rationale for choosing lubrication filters?" There are many factors that can be considered when purchasing a filter for your automobile, truck, tractor, or other equipment. The "big three" are:

- Does it "fit?" This is easily answered in any worthwhile filter company's web site where thread, gasket, burst, bypass, flow are documented along with their "guaranteed not to mess up your warrantee" vehicle application guide.
- Do you trust it to not fail or damage your vehicle until the end of the oil change interval (OCI)?[i] Attempts to answer this have resulted in people cutting apart filters and posting pictures at least since 1992. While fascinating in its own right, the studies always beg the original question. "What level of fabrication virtuosity is good enough for the OCI?"
- What is the articulate removal efficiency (does the filter "filter".) The main purpose of this paper is to gather current knowledge on this.

2 Some Technical Stuff you can skip

The first step in the data-driven approach is to check out what the current state of the art is. The best place for this is in peer reviewed journals relevant to your topic. As you would assume, there are scores of papers. I notes some here as they point out data that is frequently overlooked in this topic. Three technical papers (SAE 881827, SAE 881825 and SAE 95255) were written on how ultra-fine oil filtration affected an engine's performance. These papers described the results of micro-micro filtering crankcase oil to determine the affect of by-pass filtration in the 3- to 10-micron range. Five engine components were tested: rod bearings, bushings, compression rings, oil control rings and main bearings. The emphasis of the test was to control particles in the 3-to 10-micron range. The test proved that removing additional particles in the 3- to 10-micron range will have the greatest effect in reducing engine wear. Particles in this range have traditionally been ignored, but this size range is very significant as a long-term wear factor. In this same line of reasoning, a recent Noria publication states:"The films of oil that protect moving engine parts from wear are customarily 2-5 microns in thickness. This remains the same thickness, even when you use an additive for additional lubricity. Ergo, for example, as the pistons move up and down against the cylinder walls, particles that are as

much as 3-10 times thicker than the protective oil film are squeezed between the piston and cylinder wall. These particles are aggressive abrasives, and thereby cause substantially accelerated engine wear."ii
The next step in the data-driven approach is to determine a quantitative measurement(s) that can be used as a consistent means of comparison. As I was interested in how much junk is filtered out, then some form of size-based efficiency was needed. I quickly discovered that advertising and box labels are worthless. These use the old criteria what size of particles (in microns) are filtered using pre 1999 methods that are imprecise, and allowed for significant marketing gaming on shelf packaging and magazine advertising. For this reason, ISO 4548-12:2000[iii] Multi-pass Test was promulgated with a series of tests that introduced a more precise methodology and the "Beta rating" that provides a method of comparison. From Practicing Oil Analyst, Best Practices:[iv]
"The purpose of the multi-pass test standard is to have a lab-based procedure that will provide reproducible test data that can be used to evaluate the dirt-holding capacity and the particulate removal efficiency (Beta Ratio) of a hydraulic fluid power filter element. The test measures the particulate removal efficiency as it relates to the ingression of dirt particles creating increased differential pressure over element life (Beta Stability)."
This is superior to comparing Used Oil Analyses, as this is a controlled test where only the relevant factors are allowed to vary. Recent SAE papers demonstrate that UOA is not useful, and may be dangerous to use to evaluate the performance of a filter.[v]

3 Methodology

3.1 Filter Quality

3.1.1 Filter Quality: Fit

Unless you have a vintage vehicle, you only need to get a "vehicle application guide." It is safe to assume that the recommended filter is appropriate to and meets OEM specifications

3.1.2 Filter Quality: Construction

As I mentioned, people have been cutting open filters since at least 1992. I caught the bug at one point and was gathering filters to cut open to supplement the Beta Ratio evaluations. Fortunately, about half way through, I came across Mr. White's study[vi], which is the cleanest, broadest, most current study available. I have used this data for "construction score."

3.1.3 Filter Quality: Filtration Efficiency

Based on the SAE papers, I decided to evaluate the beta ratings in two buckets. These are less than 15 microns, and 15 to 30 microns. The data was obtained mostly from company technical literature, web sites, and company representatives. For my sample, I evaluated filters from for a diverse set of vehicles:

- 1989 Ford F-150 (5 liter, V8)
- 1999 Toyota (2 liter, 4 cylinder)
- 1985 Kubota L275 Diesel (3 cylinder, oil and hydraulic filters)
- 1963 Supercharged Avanti (289 ci, V-8)

This allowed coverage of the large, the small, the diesel, and the old. I found that within a brand, Beta ratios are very consistent. This consistency confirmed my assumption that I did not need to research any more vehicles. It also meant that I could, with reasonable safety, not pull out the "big guns" of data analysis such as ANOVA.

3.2 Ratings Methodology

- The **construction score** is straight from the White study, I have taken the liberty of assigning a graphic to his weighted score.
- The **filtration < 15 microns** graphic represents Beta data in that size range. This score is normalized to emphasize higher Beta ratios at Lower particle sizes. In other words, a Beta=10 at 2 microns is scored higher than a Beta=10 at 10 microns.(also, see note below)[vii]
- The **filtration 15 - 30 microns** graphic uses the same normalization, except that the lowest micron size evaluated is 15 microns.
- **Composite** is my weighting of the construction and the two filtration ratings. Following the three SAE studies, I have weighted the < 15 micron as twice of the other two factors. Unlike Mr. White's approach in his excellent study, I have not included price in the composite.
- **Price** is my collection of non-sale prices at automobile, big box, and "supplier" stores. Most can be bought via the internet, and there are always loss-leader sales.
- **Value.** There were too many factors for me to create a clean "value." This is left to you.

3.3 Objections to this type of Study

There are typical objections to any data-driven study. They typically question sources, dependability of data, relevance of the data, and relevance of the study. Some examples with clarifying exposition are:

- *How can you trust data from Manufacturers?*
  Three letters: FTC. As fuel and lubrication additive vendors have discovered, sooner or later FTC knocks on your door and asks for proof of any quantitative result. Also, the vendors are required to follow the ISO process to claim the ISO rating or state (to ISO) what they "tailored."
- *This study is unfair! You did not get data for all the filters, and thus created an unlevel playing field.*
  Actually, what happened is that I chose an SAE/ASME/ISO leveled playing field, and many of the manufacturers declined to play on it (provide data.) I am open to a company PoC that will provide the raw data. However, please do not send me to "tech/customer support." Been there, done that, for months
- *The only real test is how the filter works on my car.*
  True. However, how can you tell what part of good results is attributable only to the filter, and what is one of the other hundreds of variables. The current ISO test isolates the particle size variant and creates a controlled environment for that test. In all the SAE and other papers I checked, it was universally recognized that this ISO test was the best available at the current state of the art
- *The only real test is how the filter changes the UOA (Used Oil Analysis)*
  See previous bullet
- *I do not like your ranking method.*
  Fair criticism. While I cannot provide the raw data for the reasons stated above, feel free to use my bullets and re-mix the data to get a composite that means more to you.
- *ABC filter is made by the same company as XYZ filter, why do you not give them the same score?*
  There are over 100 filters in use in North America, but about 7 manufacturers. Materials, methods, and ultimate quality is set by the vendor controlling the brand. It is very sloppy data-driven technique to assume any correlation between different brands manufactured by one company.

- *Where is the raw data so I can test your conclusions?*
  Fair Question. I originally intended to include all the raw data to allow the inquisitive to challenge my methodology, starting with my raw data and expand on it. Unfortunately, as word got out that I was publishing raw data, I got some e-mails indicating that the data was proprietary. Therefore, I am only presenting composite scores; I reluctantly leave it up to you to re-gather this data.

4 Preliminary Conclusions

Purolator's PureOne is the data-driven hands-down winner. Ford's OEM filter appears to be built like a tank, but unfortunately they hold beta ratings as proprietary. In the top 5, the cheapest filter, Wix, holds up well to those more than four times as much. If you change filters with each oil change, is the extra cost of "premium" filters worth it? It is your decision.

IMPORTANT!
If you are reading this table without reading ALL of the above including the end notes you will be confused.

Filter Brand	Construc-tion Score	Filtration Score < 15 microns	Filtration Score 15 - 30 microns	Composite Score	Price	Price Score
Purolator PureOne	oooo	ooooo	ooooo	ooooo	$5.88	$
Wix/NAPA Gold	ooo	oooo	o	ooo	$4.50	$
Amsoil [viii]	ooo	DNA[1]	ooo	oo	$20.00	$$$$$
Ford	ooooo	DNA	DNA	o	$12.95	$$$
K&N	ooo	DNA	DNA	o	$11.99	$$$
Mobil 1	ooo	DNA	DNA	o	$9.88	$$
Motorcraft	oooo	DNA	DNA	o	$3.28	$
Champ	ooo	DNA	DNA	o	$8.25	$$
Denso	oooo	DNA	DNA	o	$10.95	$$
AC Delco	DNA	DNA	DNA	o	$4.14	$
Advance Auto	oo	DNA	DNA	o	$2.88	$
Baldwin	oo	DNA	DNA	o	$6.95	$$
Bosch	ooo	DNA	DNA	o	$5.99	$
C. G. Enterprises	oo	DNA	DNA	o	$3.95	$
Donaldson	ooo	DNA	DNA	o	$6.00	$
Fleetguard	oo	DNA	DNA	o	$4.28	$
Fram	DNA	DNA	DNA	o	$3.77	$
Fram TG	oo	DNA	DNA	o	$6.18	$
Hastings	oo	DNA	DNA	o	$6.95	$$
Motorcraft	oooo	DNA	DNA	o	$2.95	$
ProLine	oo	DNA	DNA	o	$2.99	$
Pro-Tec	oo	DNA	DNA	o	$1.50	½ $
Purolator Plus	oo	DNA	DNA	o	$3.24	$
STP	DNA	DNA	DNA	o	$3.19	$
Wal*Mart	DNA	DNA	DNA	o	$3.07	$

[1] Data not available

I am distressed that the chart above is mostly "DNA".
I find it sad statement of the Automotive Aftermarket Vendors that millions are spent on advertising, but they stonewall requests for quantitative data to verify those claims.
Wix is the industry golden boy here, nearly every filter has a web page with full spec.

5 Updates

If I get more data, i.e. ISO beta ratings, I will happily update this study.

6 Acknowledgements

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- For Clarification of use of Beta Ratios: Mike Day, Pall A & T Technical Group
- Purolator Pure One: Tom Duvall for professional and quick response with the requested data
- Wix: for (nearly) always having the Beta data posted with the filter's data.
- Amsoil: Paul Seminara for the Beta data
- Baldwin: Gina Johnikins for the Beta Data
- Ed White for the best lubrication filters quality evaluation, and the most current. http://home.earthlink.net/~cewhite3nc/id3.html

7 Footnotes

[i] This assumes that the Filter Change Interval (FCI) is the same as the OCI. This is the most common orthodoxy, and the assumption for this paper. However, there are some companies, and enthusiasts who make the case for FCI to be less than OCI and some for FCI greater than OCI.

[ii] How to Select a Motor Oil and Filter for Your Car or Truck, Jim Fitch ,Format: Paperback -68 pages Publisher: Noria Corporation Publish Date: 2003

[iii] ISO 4548-12:2000 Methods of test for full-flow lubricating oil filters for internal combustion engines -- Part 12: Filtration efficiency using particle counting, and contaminant retention capacity

[iv] Eric Ringholm, HYDAC Technology Corporation, "Understanding Filter Beta Ratios". Practicing Oil Analysis Magazine. January 2004

[v] Test Report: Differentiating Filter Performance By Oil Analysis Results. A multi-million mile fleet test 1997 -1999. Conclusion: Results show that the oil analysis data from the filters in the field test were deemed statistically equal. Because the oil analysis data from the filters were deemed statistically equal, oil analysis data alone is not an acceptable means of comparing filter performance.

[vi] Ed White's FL-820S Oil Filter Alternatives http://home.earthlink.net/~cewhite3nc/id3.html

[vii] Data Use Notes:

- When the manufacturer declined the opportunity to provide Beta data, even after three or more attempts, the filtration rating is set at "all black" as that is the only data-driven conclusion I can make. This also holds for any published "efficiency" that the manufacturer refused to tie to ISO 4548-12:2000. Such "data" has no meaning.
- A dangerous assumption, and one that I am making, is that I can crudely interpolate and extrapolate efficiency. The Beta Rating measures the removal of a specific size AND LARGER. My totally unsupported, if logical assumptions are:
  - For particulate sizes larger than what is reported, the element efficiency for a filter is better than the highest percentage shown for that filter.
  - For particulate sizes between two reported sizes, the element efficiency is the weighted average between the two reported data.
  - For particulate sizes less than what is reported, I make no extrapolation

[viii] I reduced the "price" of Amsoil $2.00 to reflect that as they are drop shipped from a regional center, you normally save on fuel and time over the other filters.