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ENGINE OIL FILTRATION

Filters have been standard equipment on commercial engines since 1935. Modern engine design required good filtration to maintain high level output and longer engine life. This removal of abrasive particles from air and oil before circulation through an engine is necessary to prevent damage to the highly finished metal surfaces. This is particularly true when engines are new and the concentration of abrasive fabrication dirt is large or when the engine is operating in a dusty atmosphere.

After the acceptance of filtration systems as an improvement in engine oil lubrication systems, the development and evolution of filtration methods began. The driving force behind the development of improved lubrication oil filtration was the rapid changes in engine requirements. New engine designs called for closer bearing tolerances, heavier bearing loads, higher speeds and higher temperatures. Also, during this period, the use of additive type engine oils grew commercially. These oils made possible the use of more compact full flow filters, since detergency and dispersancy reduced the element plugging and the total "dirt" holding requirements.

Non detergent oils allow fine sooty particles (by-products of fuel combustion) to join in clusters to form relatively large particles. As these suspended clusters grow, they become quite readily filtered. Detergent/dispersant oils resist the formation of soluble and insoluble oxidation products and also prevent submicron soot particles from forming clusters. The greater the level of these additives, the more the fine materials are held in suspension. Filter requirements are controlled by the combination of engine design, the type of oil, and operating conditions. Each has a variable affecting the other parameters.

Since the filter should remove all solids exceeding the thickness of the oil film separating the moving engine parts, the filter should operate in a range to remove those insolubles larger than the clearances. In spite of the continuing changes in engine design and oil formulation, the current lubrication oil filter technology retains its original goal. The filter system must protect the engine against wear from solid particles, moisture, oxidized matter and corrosive products.

The contaminants generally found in lubrication oils, that filters are expected to remove include:

Water	Airborne solids
Soot from combustion	Corrosive material (acids)
Wear solids	Oxidized material from lube oil and fuel

The amount and particle size of these contaminants will vary with the engine type, oil type and engine operating conditions(1).

A study by a filter manufacturer identified six mechanisms by which filters plug:

- Impaired Dispersaricy - A result of moisture and coolant leakage causing insolubles "dump out" of the oil. Also results from a combination of moderate soot load, low pH and a high level of oxidation products.

- Excessive Contamination – The oil becomes saturated with combustion contaminants such as soot.
- Absorption/Filtration of Oxidation Products – Fuel dilution and overheating contribute to this failure mode.
- Additive Precipitation – A result of excessive moisture in the crankcase.
- Gel Formation – Coolant and/or moisture combines with the oil additives to form a gel.
- Wear Debris and Abrasives – Excessive accumulation of these solids in the oil.

Actual filter plugging can be a result of a combination of these mechanisms. A higher quality oil helps prevent the occurrence of these filter plugging mechanisms [2].

In another study by a diesel engine manufacturer, the effect of oil filtration efficiency, air filtration efficiency and oil quality on ring wear in turbocharged diesel engines was analyzed. This study concluded that:

- The utilization of engine air filters with an initial efficiency of 99% or greater reduces piston ring wear.
- High oil filtration efficiency reduced engine component wear.
- Increased oil quality resulted in reduced oil ring wear and reduce piston deposits [3].

Figure 1 – Illustrates the results of a stud by a major engine manufacturer on the effect of filter element size and supplementation of a full-flow filter with any-pass filter on engine component wear.

In this engine test, a fine abrasive dust was added to the oil to accelerate the evaluation. The data in Figure 1 is from a test conducted to the point of engine wear-out. It indicates that improved oil filtration reduces engine component wear [4].

Figure 2 - From another engine manufacturer's study, illustrates the effect of filter life for two different micron sized pleated paper filters. This data indicates that filters with smaller micron sizes for the element are capable of long filter change intervals. However, it must be stressed that filter change intervals are determined by the type of engine, the type of oil and engine operation conditions [5].

The effects of oil detergency - dispersancy on filtration and oil ring wear was evaluated in a Caterpillar abrasive wear engine test. Figure 3 illustrates oil ring wear as a function of filter porosity for two oils of different detergent/dispersant levels. Figure 4 shows the effect of silicon content of the oil on oil ring wear for the two oils. Oil 'A' is formulated with only metallic detergents. Oil 'B' contains metallic detergents and ashless dispersants. Figure 3 indicates that improved filtration efficiency (i.e. smaller filter pores) reduces engine component wear. Abrasive wear by both oils was minimized by reducing filter porosity.

Figure 4 shows that oil ring wear correlated with silicon levels in the oil and not oil dispersancy. Filter life and contaminant dispersancy are improved by the use of higher dispersant lubricants. Increasing lubricant dispersancy had no direct effect on oil ring wear rates of diesel engines operated under non abrasive or abrasive conditions. However, by referring to Figure 2, indirect wear reduction is achieved by improving filter life with highly dispersant lubrication oils. High dispersant oils provide a cost effective means of improving engine durability via improved filter life, which reduces filtration maintenance costs and minimizes engine wear. Effective control of abrasive wear requires adequate air and oil filtration [6].

High detergent/dispersant oils increase the time before the filter relief valve opens to relieve the pressure differential across the full flow filters. The relief valve opens to insure adequate oil flow to bearings, etc. The effect of open relief valve on wear is tabulated below:

	Wear Rate Milligrams / Hour
Average new filter	2.0
Filter with relief valve open	62.2
No filter on engine	69.4

Here again is evidence of indirect wear reduction as a result of the use of highly detergent/dispersant oils. This study was conducted by a major oil filter manufacturer [7].

SUMMARY

- Higher detergent/dispersant (higher TBN) oils such as LE's 8800 MONOLEC ULTRA Engine Oil, LE's 8130 MONOLEC Ultra-Blend Engine Oil and LE's 8410-8450 MONOLEC GFS Engine Oils are capable of longer filter change intervals. However, the exact interval depends on engine type and operating conditions. This can be determined by field experience and used oil analysis using LEAP. The logical starting point is the OEM's recommended filter change interval.

- Lower porosity filter elements reduce engine wear.

- The use of smaller micron filter porosities and high detergent/dispersant oils provides the capability for extended oil and filter change intervals. LE's 8800 MONOLEC ULTRA Engine Oil, LE's 8130 MONOLEC Ultra-Blend Engine Oil and LE's 8410-8450 MONOLEC GFS Engine Oil will work better (less plugging) than other oils with the smaller porosity filters. Actual size recommendations should be made on the basis of OEM recommendations and field experience.

BIBLIOGRAPHY FOOTNOTE[1] SAE Paper 740518; [2] SAE Paper 780974; [3] SAE Paper 852125; [4] SAE Paper 710813; [5] SAE Paper 680258; [6] SAE Paper 670957; [7] SAE Paper 650866

Figure 1: The Effect of Filtration Efficiency on Engine Component Wear

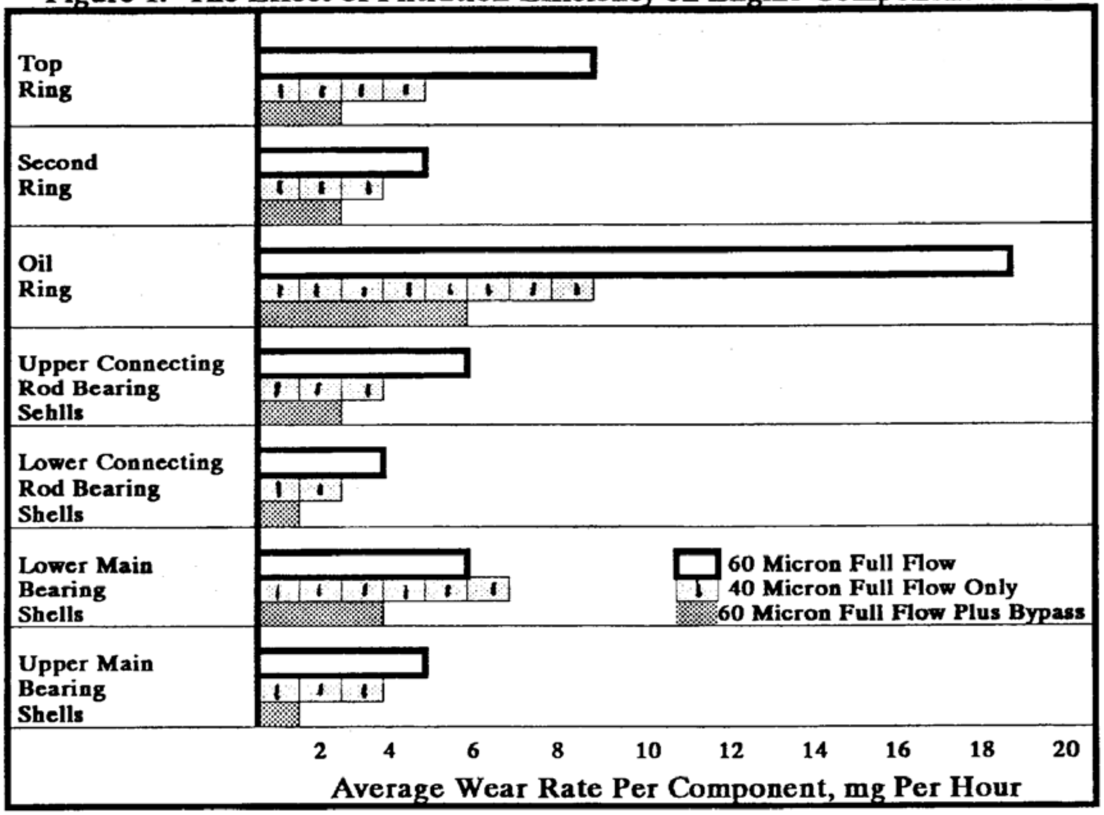

Figure 2: Effect of Filter Life on Engine Wear

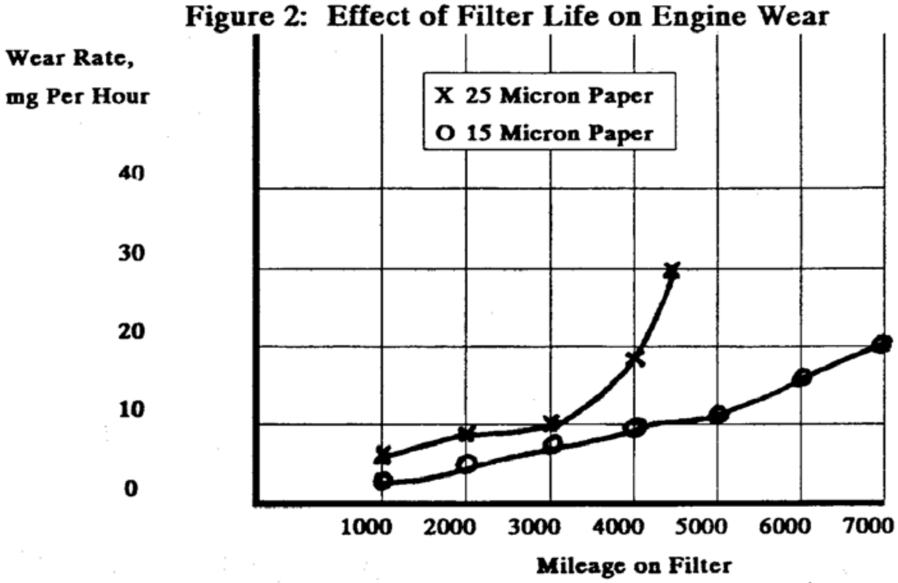

Figure 3: Oil Dispersancy Level and Oil Ring Wear

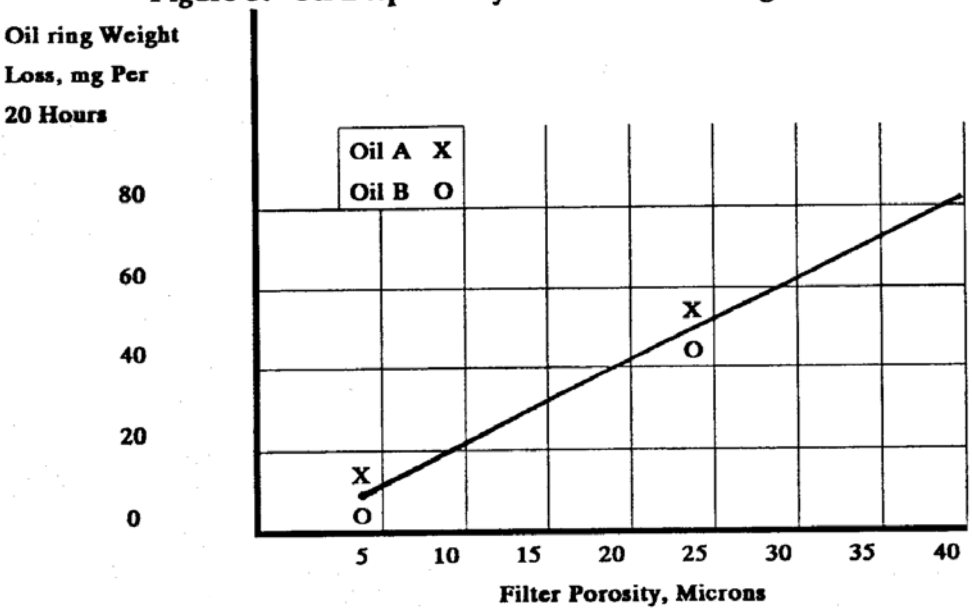

Figure 4: Oil silicon content Effect on Oil Ring Wear