Trends in Automotive Lubricants

Engine Oil Quality and the Need for Its Assurance

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General Introduction

Most engine oils are made to acceptable standards of quality. Even so, they can vary widely both in general and in particular qualities. Then, of course, there are engine oils that are of poor quality and put on the market for reasons of ignorance or greed. Unfortunately, for the uninformed automobile owner, an engine oil of appropriate quality and one of poor quality both look and feel the same. Without an alternative source of reliable information regarding engine oil quality, the automobile owner is left with his engine being the recipient and witness of a good oil's benefits or a poor oil's costly adverse engine effects.

One of the purposes of this paper is to bring attention to an alternative source of information on engine oil qualities. In addition, the paper will show several examples of how such information can be used to more broadly observe the benefits and limitations of formulation and manufacturing practices resulting in the broad range of available engine oil quality.

The Relation of Engine and Bench Tests

Either in field use or in dynamometer tests, the automotive engine has always been the ultimate platform for identifying the needed quality of its engine oil. Even as engine design has changed to meet performance, fuel efficiency and environmental desires, the engine has always been the ultimate arbiter of engine oil quality.

However, using the engine to measure the quality of the engine oil in dynamometer tests is a very expensive path even for automotive experts. Even so, to help control warranty costs, development and use of engine tests is an unavoidable path for engine manufacturers when determining the level of engine oil quality that is required for the particular design of engine or its components. In addition, generating dynamometer tests of an engine, while necessary, is challenging since it is technically difficult to establish engine tests that are repeatable even to a fair degree. Further, as engine design has progressively increased power from smaller engines, the difficulty of generating repeatable dynamometer tests has grown even more rapidly.

Fortunately, once this quality level has been determined for engines either on the dynamometer or in the field, there is a much less expensive technical approach that can then be developed and applied to much more precisely appraise oil quality. This approach is the use of laboratory bench tests designed and developed to correlate closely with engine dynamometer tests or field experience. This approach is well known to the lubrication experts who set specifications for engine oil quality levels. Once developed, such bench tests are not only dependable but can be held constant over years or if desired changed knowledgeably to accommodate newer engine designs since the basic engine chemistry remains the same.

Often such bench tests make it possible to characterize the quality of engine oil where use of a dynamometer engine test is either very difficult or unlikely to be reasonably possible. This has happened several times over the past decades. In such cases, it has been field problems that have revealed the need for developing a bench test and provided the basis for bench test correlation rather than engine dynamometer tests.

Need for Meaningful Bench Test Methods to Determine Engine Oil Quality

Understandably, bench tests that correlate with the automotive engine have the capability of providing a good and relatively inexpensive measure of engine oil quality. However, the value and significance of a bench test is highly dependent on

1. careful identification of the specific needs of the engine requiring a bench test,
2. sufficiently clear and relatively consistent information from the engine either in dynamometer tests or field experience, and
3. thorough understanding of the relationship between the apparent needs of the engine and how these needs are related to the physical and/or chemical properties of the engine oil.

Application of these three factors is always limited by the experience and training of those expected to develop a bench test and new engine needs often bring the challenge of new levels of understanding. It has happened that a few bench tests have been developed that unfortunately were found to have little relevance to what they were claimed to measure and some, in fact, measured an entirely different property which appeared to be the property sought [1].

To serve the engine, the engine oil should possess a number of physical and chemical properties during its use over the time between oil changes. However, during the oil's service in the engine – which service conditions may vary widely depending on both the way the vehicle is used and the environmental conditions – the engine generates a number of operating stresses that adversely affect the long-term ability of the engine oil to function at a consistently high level. Consequently, choice of engine oils to meet particular service needs and conditions requires knowledge of the oil quality level needed as well as appropriate oil-change intervals. As engine design has steadily improved the engine's performance and efficiency, the need for careful formulation and understanding of engine needs has similarly grown – as has the need for informative bench tests.

As important to the engine owner is the need for a clear source of information regarding engine oil quality for different service and environmental conditions. Fortunately, such information has been available for several decades in the form of a number of well-regarded and precise bench tests.

The Institute of Materials Engine Oil Database

Thirty years ago, based on a high level of concern expressed by engine manufacturers about the quality level of some engine oils being marketed, the Institute of Materials (IOM) began to make available an engine oil database where engine oils would be collected by the hundreds directly from the market and thoroughly analyzed with a series of more than two dozen relevant bench tests by selected laboratories. These results were published and the database now covers over 14,000 engine oils world-wide.

This paper will discuss bench test studies of four of the important properties and qualities of engine oils using data from the IOM database on engine oils collected from North and South America over the years from 2008 to 2014. The authors will show application of specific bench tests to compare performance of engine oils and in addition, show the degree to which these properties have varied over these recent years.

Technical Considerations

Engine oil is sometimes described as the "life-blood" of the engine. The analogy is good since just as animal blood, the engine oil performs a number of important positive functions. These include:

1. Prevention of wear through hydrodynamic lubrication.
2. Absorbing and dispersing engine heat.
3. Retarding oxidation, sludge formation and deposit formation.
4. Carrying suspended particles to a place of filtration.

The analogy to blood continues in that it is also true that the engine oil carries the potential for causing undesirable responses – particularly if poorly formulated. Some of these undesirable responses associated with desirable properties will also be discussed in this paper.

Engine Oil Viscosity

Fundamentally, viscosity may be defined as a fluid's resistance to flow. To explain: because the molecules of a fluid are somewhat attracted to one another at a molecular level, energy is required to pull them apart to cause flow. In general, larger molecules have more attraction between them and higher viscosity.

The energy required to overcome this molecule-to-molecule attraction and cause fluid flow can be considered a form of friction and, so, viscosity can be defined as a form of molecular friction. Of all of the engine oil's physical and chemical properties, its viscosity and viscometric behavior during use is often considered the most important of its properties. As will be shown, viscosity has both good and bothersome properties.

Viscosity and Wear Prevention – Fortunately, this same 'molecular friction' prevents the engine oil from escaping too quickly when two engine surfaces in relative motion are brought closely together under pressure. This inability of the intervening oil to escape quickly and its level of incompressibility holds the two surfaces apart and prevents wear – a process which has been termed 'hydrodynamic lubrication'[2]. It is evident that the higher the viscosity, the greater the attraction of the oil molecules and the greater the wear protection. The effect is even greater in the direction of motion of one surface over another since there is a tendency for larger molecules to orient somewhat in the direction of motion of the oil mass.

Classification of Engine Oil Viscosity – The viscosity of the lubricant has always been associated with wear protection. As a consequence, from early in its history, 1911, the SAE* has recognized viscosity level as important to engine function. Accordingly, the SAE* instituted the engine oil Viscosity Classification System J-300 [3] to establish viscosity levels for engines by a series of Grades* defined by viscosity levels in one or two temperature zones.

Today these Grades (see footnote) are set for the engine operating temperatures and for winter temperatures at which the engine oil affects starting and pumping.

Viscosity of Engine Oils at Engine Operating Conditions – In the earlier years of the automotive engine, the engine oils were simply formulated with the oil and additives and obeyed Newton's equation for viscosity [4]. That is, the more force brought to make it flow (called 'shear stress'), proportionately the faster the fluid would flow (called 'shear rate'). Essentially, the ratio of shear stress to shear rate – the viscosity – remained constant at all shear rates. The engine oils of that time were all essentially single-grade and carried no SAE 'W' classification.

This viscometric relationship changed in the 1940s when it was found that when small amounts of comparatively high molecular-weight soluble polymer were added to the engine oil, using the low shear rate instruments then available, the oil would seem to have the flow characteristics desired for both low-temperature starting and for higher-temperature engine operation. Accordingly, these polymer-containing oils became listed by the SAE Viscosity Classification System as 'multi-Grade' engine oils [5] – meeting the requirements of both temperature zones of viscosity.

Since that time, multi-Grade oils (i.e. SAE 10W-40, 5W-30, 0W-20, etc.) have become very popular. However, these multi-Grade oils were no longer Newtonian in flow characteristics – the

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*Engine oil viscosity levels are established by Grades set by the Society of Automotive Engineers (SAE) for both engine operation temperatures (i.e. commonly, 20, 30, 40, etc.) and initial low-temperature starting and pumping temperatures (i.e. commonly 0W, 5W, 10W, etc.). These viscosities levels are set by the SAE Viscosity Classification System, J-300.

viscosity was found to decrease with increasing shear rate. This was considered important in lubricating the engine which operated at very high shear rates – shear rates measured in millions of reciprocal seconds ($^1/_s$ or s^{-1}) – in contrast to the several hundred reciprocal seconds of the low shear viscometers then being used to characterize engine oils.

High Shear-Rate Viscometry – Consequently, a need arose to develop a high shear rate viscometer as a bench test to reflect the viscosity in the engine under operating temperatures. In the early 1980s, an instrument and technique was made available which was shown to be able to reach several millions of reciprocal seconds at 150°C [6] as well as to similarly exert high shear rates at other temperatures such as 100°C on both fresh and used engine oils [7]. The instrument was called the Tapered Bearing Simulator Viscometer and the method was accepted by the ASTM in 1987 as Test Method D4683 for use at 150°C [8] and more recently as D6616 for use at 100°C [9]. (Interestingly, it was later shown that this instrument was unique and basically absolute in providing measures of both shearing torque or shear-stress and shear-rate while operating. As far as is known, it is the only viscometer capable of doing this.)

This critical bench test of engine oil quality became known as its High Temperature, High Shear-Rate (HTHS) viscosity and minimum limits were imposed for various Grades in the SAE Viscosity Classification System.

Viscosity and Oil Gelation at Low Temperatures – The original reason for introducing multi-Grade engine oils was to reduce the viscosity of these oils at low temperatures to aid in engine starting [10]. The benefit was immediately apparent and multi-Grade engine oils have since become the most popular form of engine lubricant around the world.

With easier engine startability at low temperatures, another problem previously hidden by difficult startability became evident -- engine oil pumpability. This was a considerably more serious problem in that lack of engine oil pumpability to lubricate the engine could destroy the engine while lack of startability was a non-destructive matter of frustration. In engine cold-room dynamometer tests it was shown that there were two forms of pumpability problem. The first was simply related to high viscosity and called 'Flow-Limited' behavior [11].

The second was considerably less obvious and involved the gelling of the oil under a sufficiently long and deep cooling cycle and was called 'Air-Binding' [12] since after pulling a column of oil reaching to the surface of the oil in the sump, the oil would not fill this void and the oil pump became air-bound as shown in Figure 1.

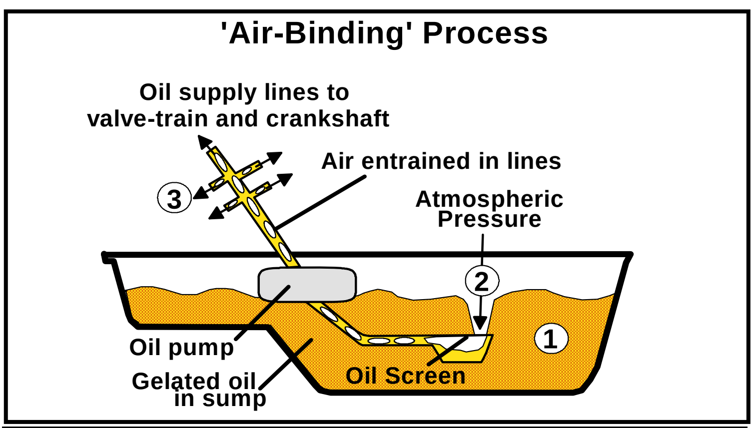


Figure 1 – Showing (1) structured oil, (2) hole pulled in gelated oil to operating oil pump by atmospheric pressure and (3) air being pumped to lubrication sites of the engine.

Despite this knowledge plus an instrument and bench test that had originally seemed to predict both forms of failure, this was found not enough. In the winter of 1979-80 in Sioux Falls, South Dakota, a cooling cycle showed that Air-binding could occur under what seemed relatively mild cooling conditions [13]. Over a 24-hour period a number of engines containing a well-respected brand of engine oil were ruined.

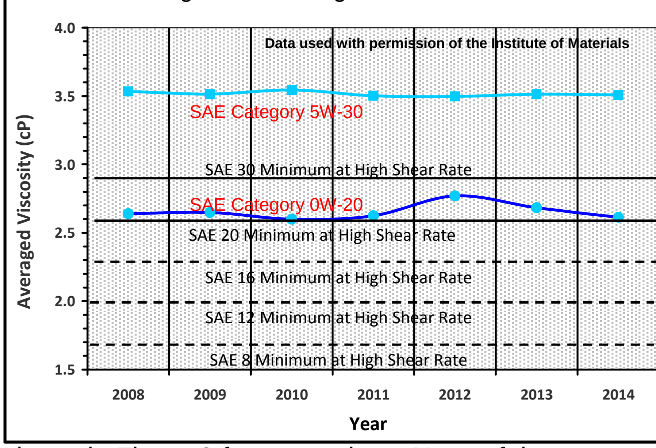
The cooling cycle over that period had produced a condition in which the engine oil had become Air-Bound. The costly incident indicated the need for a more sensitive bench test that would accurately predict any tendency to cause Air-Binding pumpability failures.

The Gelation Index – The Air-Binding engine oil which caused the Sioux Falls failures provided a solid basis of study. A new bench test instrument and technique was developed that by continuous very low-speed operation of a cylindrical rotor in a loosely-surrounding stator revealed any tendency of the test oil to gelate [14]. This instrumental technique was immediately incorporated in engine oil specifications and later became ASTM Test Method D5133 [15]. It not only gave any tendency of the engine oil to be Flow-Limited but also produced a measure of the degree of any gelation that might occur over the temperature range of measurement (usually -5° to -40°C) with a parameter called the Gelation Index [16]. Today engine oil specifications for multi-Grade oils require a maximum value of Gelation Index of 12 – a value deliberately set to be below the minimum level of 16 shown by the most difficult to gelate Sioux Falls failing oils.

Viscosity and Energy Absorption – As important as the property of viscosity is to the engine in preventing wear through hydrodynamic lubrication, the property also has some negative aspects which affect engine operating efficiency. The previously mentioned 'molecular friction' of the oil separating two surfaces in relative motion also requires energy to overcome that oil friction – a significant amount of energy from the engine in exchange for the wear protection it provides. Thus, careful formulation of the engine oil viscosity by choice of base stock and additives that affect viscosity is also very important to the automobile owner – and to those governments mandating fuel economy targets such as the United States. For this reason, lowering the oil viscosity is important in reducing viscous friction to improve fuel efficiency. Interestingly, over the last several years, there has been an increase in the number of automobiles that can operate with engine oils having lower viscosity levels than ever before thus markedly improving their engine efficiencies.

A decade ago, the lowest SAE Viscosity Grades were SAE 0W-20 and 5W-20 oils with SAE 20 carrying the minimum high shear-rate viscosity of 2.60 cP (centiPoise) to simulate engine operation at 150°C. IOM data on such marketed engine oils for North and South America are shown in Figure 2 as are data for SAE 5W-30 engine oils.

Figure 2 Engine Oils At High Shear-Rate and 150°C

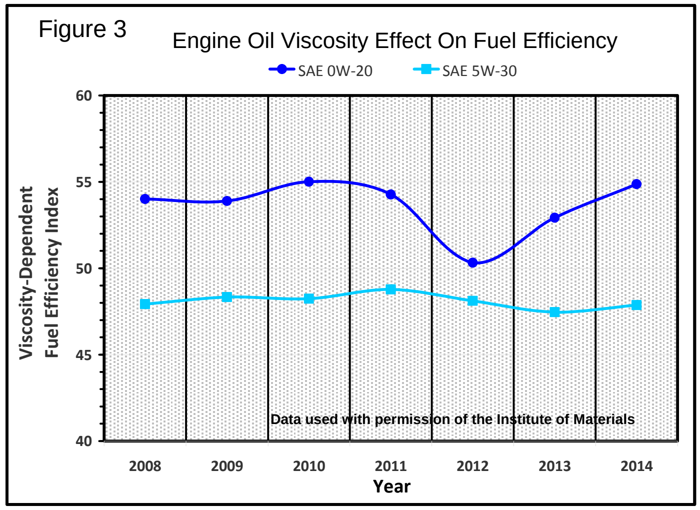


Japanese automakers have recently called for even lower Grades. As a consequence, the SAE has introduced three new operating viscosity Grades identified as SAE 16 (2.30 cP minimum at 150°C), SAE 12 (2.00 cP minimum at 150°C) and SAE 8 (1.70 cP minimum at 150°C) [17]. These Grade requirements are also shown in Figure 2 for comparison. None of these lower Grade level oils are yet reaching the popular markets for IOM analyses. Since viscosity is directly related to the amount of energy expended by the engine in wear protection by hydrodynamic lubrication, such decrease in viscosity would be expected to have important benefits in fuel efficiency -- but only in engines designed for their use – (an important caveat).

The Viscosity-Dependent Fuel Efficiency Index – In view of the influence the engine oil viscosity has on engine efficiency, a technique was developed to calculate the effects of engine oils on fuel efficiency [18]. To be meaningful, the viscosity values used had to be obtained at the high shear-rates associated with engine operation in particular sections of the engine.

Earlier dynamometer work had developed the percent of friction and operating temperature of the five important lubricating sites in the reciprocating gasoline-fueled engine responsible for nearly all efficiency loss [19]. This information was used to develop the parameter of the Viscous Fuel Efficiency Index (V-FEI), a value ranging from 0 to 100 in which the higher the value of V-FEI of a given engine oil, the less engine energy lost to viscosity and, consequently, the more fuel efficient the engine [20]. Although different engine designs might have different levels of friction in the five different important lubricating areas of an engine, use of the friction data from this one older engine provides a relative, comparative value for engine oils to one another.

Figure 3 shows the average value of SAE 0W-20 and 5W-30 engine oils collected from the markets of North and South America during the years from 2008 to 2014. For comparison, the average V-PEI for SAE 0W-20 and 5W-30 in an earlier 2004 paper was 46 and 47 respectively.

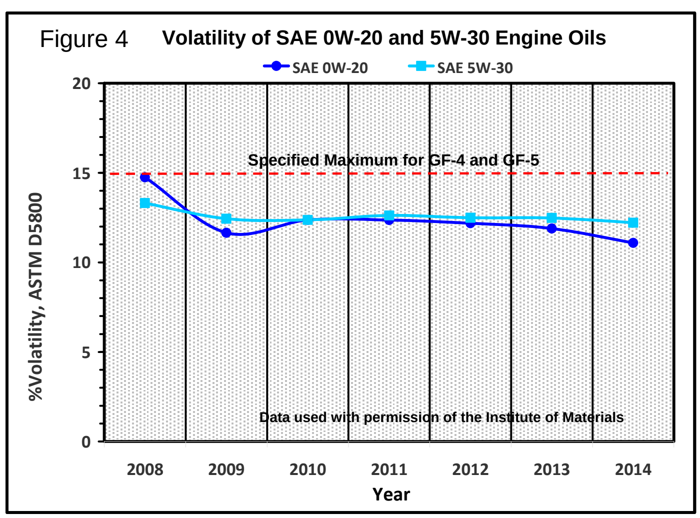


It will be observed that, as expected, the yearly averaged multi-Grade SAE 0W-20 oils contribute more fuel efficiency to the engine than do the averaged multi-Grade SAE 5W-30 because of the viscosity differences shown in Figure 2. With the exception of the year 2012, the increase in V-FEI shown by the difference in the two SAE multi-Grades is equivalent to about 7 to 8% in viscosity-dependent fuel efficiency.

The decrease shown in the average fuel efficiency of the SAE 0W-20 engine oils collected by IOM from the market in 2012 is interesting and may indicate the development of formulations meeting concerns of automakers that the benefits of hydrodynamic lubrication will not be lost in the effort to improve fuel efficiency.

Engine Oil Volatility

Reduction in the viscosity of engine oil formulations has another aspect that is important to consider. Such reduction is most frequently obtained by the use of base oils having higher volatility. Higher volatility has three effects on the engine depending on the degree of volatility.



First of all, volatized oil reduces the amount of engine oil serving the engine. Secondly, the volatilized oil may carry exhaust catalyst-contaminating components and negatively affect the catalyst's smog-reducing ability. Thirdly, the oil remaining after loss of its more volatile components will be more viscous and energy-absorbing for reasons already presented.

Figure 4 shows the response of two of the most volatile multi-Grade classifications of engine oils. Also shown is the specified maximum volatility set by the International Lubricant Standardization and Approval Committee (ILSAC). In the last few years, it is evident that these two classification categories of SAE 0W-20 and 5W-30 were formulated to meet the volatility specification of ILSAC by a comfortable performance margin. Such results suggest that volatility control may be less demanding with even the more newly classified multi-Grade oils recently identified as SAE 0W-16, 0W-12 and 0W-8 that were earlier mentioned.

Phosphorus Emissions and Volatility

Soluble organic phosphorus compounds such as zinc di-alkyl di-thiophosphates are important anti-wear and antioxidation compounds which have been used frequently in formulating engine oils over many years. These compounds gave considerable support to the design of modern engines.

Starting in the middle 1900s, the reciprocating engine was clearly identified as a contributor or cause of heavy – and, at times, dangerous – air pollution. Unburned or partially-burned hydrocarbons from the engine exhaust were modified by sunlight into noxious gaseous hydrocarbons which produced heavy so-called ‘smog’ in some large cities. Illnesses and deaths were attributed to these conditions. As a consequence, exhaust catalytic converters were developed in the 1970s to treat the exhaust gas and convert it into CO_2 and water.

Unfortunately, in the years shortly following the development of the catalytic converter, it was found that some of the contents of the gasoline or the engine oil, such as phosphorus and sulfur, would deactivate the catalyst by coating it. This ultimately led to restrictions, such as those of ILSAC GF-5 [21], of the quantity of such chemicals present in the engine oil and fuel. However, as a result of development of another bench test to measure volatility, it was found that concentration of phosphorus and sulfur in the engine oil was not necessarily related to concentration.

The Phosphorus Emission Index – The Selby-Noack volatility test was developed in the early 1990s [22] as a better and safer approach for determination of engine oil volatility than the earlier Noack which used toxic Wood’s Metal [23]. Moreover, the two instruments correlated very closely in the percent volatilization of samples. The primary performance difference between the two instruments was that the Selby-Noack procedure also collected the volatile component of the volatility test for further physical and chemical analysis. This turned out to have a significant advantage in regard to detection of phosphorus and sulfur emitted in volatilization.

In first analyses of the volatiles collected from the Selby-Noack bench test it was evident that the phosphorus additives in the engine oils were also producing phosphorus through additive decomposition [24]. On the basis of these findings a parameter related to the amount of phosphorus released in the Selby-Noack test per liter of engine oil was developed called the Phosphorus Emission Index (PEI) [25].

Figure 5 shows the change in PEI over the last eight years. It is evident that considerable progress is being made in reducing the phosphorus decomposition and/or volatility of these two relatively volatile multi-Grade SAE classifications. The reduction of the PEI to levels of 6 to 10 milligrams per liter of engine oil in the engine from levels that have been found in the formulations of earlier years to reach over 60 mg/L is a very significant change in protecting the catalytic converter from the effects of phosphorus.

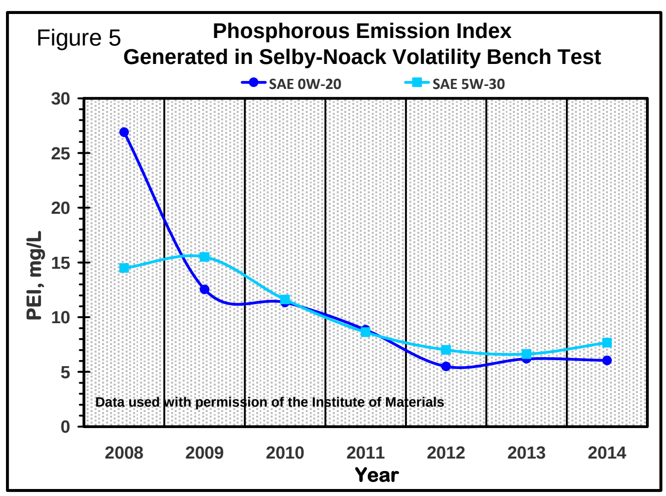
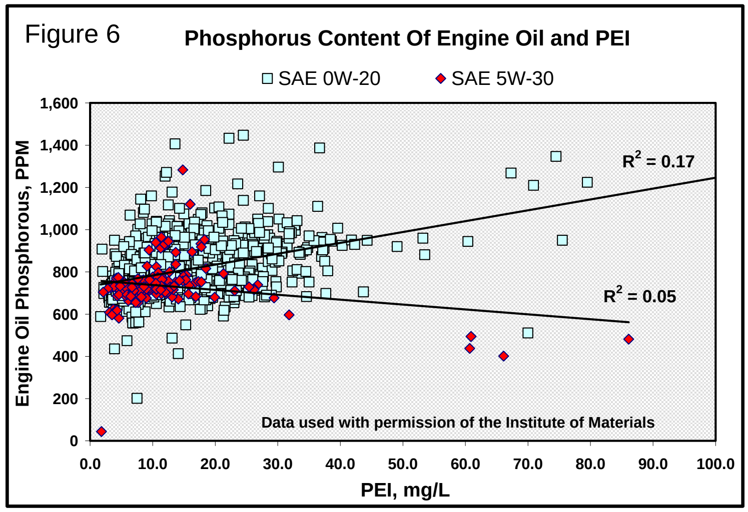


Figure 5 Phosphorous Emission Index Generated in Selby-Noack Volatility Bench Test

With the trend today to smaller fuel efficient and turbocharger-equipped engines generating higher temperatures during operation, a bench test that can reveal the phosphorus emission tendencies of an engine oil formulation provides data important to the design of lubricants best suited to the service of the engine and the environment.

Phosphorus Content and Volatility – As mentioned, the influence of phosphorus content in the engine oil on the amount of phosphorus volatilized during engine operation is an important question affecting the choice of additives in the formulation of the engine oil. Data contained in the IOM Engine Oil Database was used by the authors to answer this important question about the interrelationship.

Figure 6 is a plot of the phosphorus content of a number of SAE 0W-20 and 5W-30 engine oils versus the PEI values obtained. The best lines through the data collected over seven years in the IOM Engine Oil Data-Base are also shown for both Grades as are the values of the Correlation Coefficient, R^2.



The data clearly show that phosphorus volatility generated by the Selby-Noack test is virtually unrelated to the amount of phosphorus present in the oil as an additive.

The lack of correlation between the concentration of phosphorus in the engine oil and the amount of phosphorus volatilized is numerically evident in the low values R^2. This parameter would be near a value of $R^2 = 1$ if phosphorus concentration affected its volatility. Rather, as shown in Figure 6, the values obtained from the data are much lower with $R^2 = 0.05$ for SAE 0W-20 and $R^2 = 0.17$ for SAE 5W-30 engine oils.

The PEI data are primarily clustered at values from 2 mg/L to about 30 mg/L. However, a small number of PEI values exceed 40 mg/L and these engine oils are likely to be more harmful to the exhaust catalyst. However, as has been shown in Figure 5, PEI levels have been decreasing markedly over the last few years.

Summary and Conclusions

Summary

In this paper four of the number of important properties of engine oils were presented and discussed with the primary purpose being to bring attention to the importance of the oil's quality in serving the engine. Without question, the quality of engine oils will play a much greater role in the smaller, turbocharged, more powerful and responsive engines that have entered or are about to enter the automotive market.

However, it is essentially impossible to determine the quality of a given engine oil by appearance. Determination of engine oil quality is only evident 1) in the use of the oil or 2) in pre-tests of quality. The latter is much to be preferred for the automobile owner who has such high investment in, and need for, a well-functioning and durable engine. Data from the Institute of Materials Engine Oil Database is the most complete public source of such information (www.instituteofmaterials.com/)

and this source was utilized in obtaining the data on the four aspects of engine oil quality given in this paper.

Viscosity

This paper emphasizes the importance of the viscosity of the engine oil both in its positive aspects of lubricating the engine and its negative aspects of low-temperature pumpability as well as its effect on fuel efficiency.

Engine oil formulation has always been important to engine oil quality but in very recent years the qualities important to modern and forthcoming engines have made formulation practices and understanding critical to engine function. Viscometric bench tests at high temperatures are essential to assuring that quality, as has been shown by the Institute of Materials Engine Oil Database. The data presented herein shows that for the last several years HTHS for lower viscosity multi-Grade engine oils are meeting specifications of the SAE Viscosity Classification System.

It will be of interest in the near future to see how the new SAE perform in these HTHS bench tests and in the engines made for their use.

Fuel Efficiency

The relationship between viscosity and its effect on fuel efficiency has led to the development of a new parameter called the Viscosity-Dependent Fuel Efficiency Index, V-FEI. Analysis of this V-FEI parameter for lower multi-Grade engine oils showed that recent values for lower viscosity multi-Grade engine oils are improving and are considerably higher for the SAE 0W-20 at a V-PEI of 55 than the value of 46 obtained in 2004.

The forthcoming introduction of the new, even lower SAE multi-Grades of SAE 0W-16, 0W-12 and 0W-8 have promising potential for increased fuel efficiency in the engines made for their use (but, according to expressed concerns of automotive experts, poor durability expectations in older engines not made for these less effective levels of hydrodynamic lubrication.)

Volatility and Phosphorus Emissions

As has been shown earlier in this paper, any volatility of the engine oil has several aspects, some of which are more important than others.

Volatility and Lower Operating Viscosity – Any volatility of the engine oil is a loss of lubricant if it escapes the engine. Consequences vary with rate of lubricant loss and how that loss affects both the base oil and the additives it carries. Moreover, in engines equipped with a turbocharger also lubricated with the engine oil, there can also be volatility effects and loss of additives.

Present and, likely, future emphasis on lower viscosity multi-Grade engine oils will focus more attention on ways of controlling loss of lubricant. It would be expected that more attention will be given to the use of synthetic and bio-oils because of the ability to select base oils with much more limited range of volatile components. The information shown in Figure 4 from the IOM Engine Oil Database does not yet show change in this direction of formulation. However, the information on the low viscosity SAE multi-Grades, 0W-20 and 5W-30, does show a consistent volatility loss value over the last few years in the range of 12% to 13% -- comfortably below the present maximum of 15%.

The Phosphorus Emission Index – The efforts to control so-called ‘smog’ also has increased sensitivity to the effects of phosphorus and sulfur in poisoning the exhaust catalyst appended to the engine to essentially eliminate this automotive contaminant of the atmosphere.

The data from the Selby-Noack volatility instrument (which collects the volatilized oil) showed that phosphorus is actually generated by decomposition of some engine oil additives. However, prior to this information, under the assumption that the phosphorus content of the oil was the cause of catalyst poisoning, 800 PPM maximum was set on phosphorus in ILSAC GF-5 automotive engine oils.

The data presented in this paper shows that phosphorus volatility has been reduced markedly in the last few years as a result of better formulation practices.

Conclusions

In the course of a little more than a century, the automobile has become the dominant device progressively freeing mankind from his immediate surroundings and limitations. One of the most important parts of this freedom is the growing dependability of the automobile. With that growing dependability has developed a growing complacency which is only occasionally bothered by unfortunate problems stemming from the fact that the engine and its engine oil are the heart, muscles and blood of this mechanical conveyance.

As the automotive engine is pushed to higher levels of power, fuel efficiency, clean and clear exhaust and overall satisfaction, the quality level of engine oil will become a more necessary need for the motorist. To what degree the motorist will have to become reasonably knowledgeable about engine oil quality is uncertain. However, sources of knowledge such as the Institute of Materials Engine Oil Database, will become more necessary and very likely the motorist will become more sensitive to the protection of the engine.

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