LUBE-TECH

NO.12

# UNDERSTANDING TODAY'S ENGINE OIL SPECIFICATIONS

The first in a series of BLF Fact Sheets has recently been issued, it covered AUTOMOTIVE ENGINE OILS. Its main purpose was to help end-users and the retail trade to understand today's complicated automotive engine oil specifications. Our first Fact Sheet has generated much interest from regional newspapers, as well as from specialist trade journals and more popular magazines. The Fact Sheet's secondary purpose was to highlight to the trade the existence of the British Lubricants Federation and allow the BLF to communicate with the trade and lubricant end-users, possibly offering specific Lubricants Training if there is enough demand.

This article is directed mainly at motorists and the motor trade who are without specialised knowledge of lubricants. It explains in more detail the differences between engine oils and the importance of using the right oil for the vehicle's engine.

## GENERAL BACKGROUND

The BLF's LUBE quarterly magazine has in the past been circulated mainly to BLF members and to those particularly interested in lubrication information. Technical articles have been of an appropriately specialist nature to be of interest to the majority of readers, i.e. those who already have some knowledge of lubricants. ***However, the specialist may not always fully appreciate the lubricant-purchasing public's lack of lubricant knowledge.***

As cars become increasingly more sophisticated and reliable, there is less and less requirement for the motorist to become involved in the servicing and trouble-shooting aspects of his or her vehicle.

The majority of cars are now garage serviced, and reputable garages will (or should!) use engine oils of the quality stipulated by the vehicle manufacturer for that particular model. Owners of older vehicles may undertake some servicing themselves, one of the most important aspects of which is the regular changing of the engine oil.

This involves the DIY owner in making a choice from the bewildering array of engine oils available. Unlike the vast majority of consumer products, there are few clues available to the layman to gauge relative qualities when comparing one engine oil with another, apart from the information on the container. ***All too often, this information is confusing to the layman, who may not be aware of the significance of viscosity grades, and is even less likely to be aware of the niceties of performance claims.***

We believe there is currently a situation of confusion, influenced by an array of products at various prices and a distinct lack of knowledge. A significant number of purchasers seem to concentrate on price rather than quality, probably through a lack of knowledge. Purchases made solely based on price, rather than a product's true quality and performance, plus the track record of the brand may lead to catastrophe. Normally one should expect an oil that costs as much as ten times the price of another will perform rather better than its 'bargain basement' priced competitor.

The motorist and probably many trade buyers mistakenly believe that cheaper brands can be just as good, even at their substantially lower price, because they don't know how to differentiate between brands. Choosing your motor oil this way can result in your engine being 'fed' on the wrong product, one which could immediately cause a massive increase in internal friction and considerably reduce the useful life of the motor.

There is also the current impression of a 'rip-off Britain' attitude portrayed by the media, sometimes with some justification, whereby the public suspect they are being over-charged.

DIY owners may well be tempted to opt for the cheapest available product, which is all too often available from established high-street retailers, on the basis that all oils are the same and that there is no justification in paying any more than the absolute minimum. We are not decrying low prices or value for money products, that's OK, provided the purchaser wants to buy them, after making an informed choice. We are striving to help educate lubricant purchasers, so that an informed choice can be made thereby avoiding putting expensive motors at risk.

## HISTORY

The performance and longevity of passenger car and commercial vehicle engines have increased markedly over the years due to continued development and improvements in engine design, materials of construction and last, but not least, lubrication technology.

As a consequence, the owner of a typical passenger car can now expect engine mileages in excess of 150,000 without major mechanical overhaul, provided that the vehicle has been serviced according to the manufacturers recommendations, which would include the need for using oils of the correct specification.

Before the harmonisation of European legislation (Treaty of Rome), vehicle manufacturers recommended lubricants by manufacturer and/or brand name. By specifying only well-known and reputable lubricant manufacturers such as BP, Castrol, Duckhams, Esso, Mobil, Shell, Texaco etc., the manufacturer could ensure that vehicles were properly lubricated according to the best technology of the time.

With the subsequent outlawing of such restrictive practices, vehicle manufacturers who had previously nominated a specific lubricant by name had now in addition to provide details of the minimum required lubricant specification, thus providing a choice for the consumer.

The customer, whether a service workshop or do-it-yourself owner, was then free to choose any lubricant conforming to the specification stipulated in the handbook or service manual, regardless of lubricant manufacturer. The use of such specifications in fact pre-dated the European legislation requirements, but they obviously came into more prominence following the outlawing of the practice of specifying lubricant quality by manufacturer or brand name alone.

These lubricant specifications cover two areas of lubricant requirements, namely the VISCOSITY requirements and the PERFORMANCE requirements.

## VISCOSITY REQUIREMENT.

Viscosity quite simply is the 'thickness' of an oil. It is important that oils of the correct viscosity are used. If the viscosity of the oil is too thick (high viscosity), the engine will be difficult to start, particularly in cold weather. Also, because the oil is more difficult to pump, the oil will not reach all parts of the engine quickly enough after initial startup to prevent wear taking place. If the viscosity of an oil is too thin (low viscosity), there is a danger that the lubricant film will break down in bearings, allowing metal-to-metal contact to take place, which will produce rapid wear.

Multigrade viscosity motor oils are now universally used in the UK, probably the most common being 10W/40. They were introduced primarily to allow the same grade of oil to be used in summer and winter.

A vehicle manufacturer will normally stipulate a range of viscosity grades in the vehicle handbook, depending on typical local ambient temperatures in the region in which the vehicle is normally used. Oil viscosities are normally clearly displayed on containers destined for the retail market, and the identification of an oil meeting the correct viscosity requirement is a relatively straightforward process for the consumer.

More recently, developments in lubricant technology have enabled oils of lower viscosity than those normally stipulated to be safely used. In these oils, adequate film strength and low volatilities, previously unobtainable in oils of such low viscosities, are the result of advances

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in base fluid and additive technology. Engines using these new high-tech low viscosity oils show benefits in terms of improved fuel consumption due to the reduced internal frictional losses resulting from by viscous drag and oil churning.

## PERFORMANCE REQUIREMENTS

This aspect is considerably more complex than the viscosity requirement. Motor oils are manufactured from a blend of base fluids, either mineral oils (base oils) or synthetic chemicals, together with a series of additives, which improve the properties of the base fluid, or impart additional properties. It is the combination of the base fluid and the additives which together result in the overall performance of the motor oil.

These performance specifications are being steadily increased in severity as the technology of both the motor oils and vehicles is being improved. Oils, which were developed, for vehicles of the 1950's, the 1960's, the 1970's and even the 1980's are not suitable for the engines of today.

Lubricant performance specifications are set primarily by technical trade bodies such as Association des Constructeurs Européenne d'Automobile (ACEA) and the American Petroleum Institute (API). Certain motor manufacturers, e.g. Volkswagen, Mercedes Benz, Porsche etc. may impose their specific additional requirements on top of the range of engine tests, which incorporate ACEA's or API's main specification.

The vehicle manufacturer will also specify the intervals at which the oil is to be changed, on the assumption that the correct specification oil is being used. Oils which do not conform to the required specification, and contain low levels of additive, are almost certain to fail within the oil change period.

Before any lubricant manufacturer can claim a particular level of performance, samples of the oil must undergo a whole series of closely monitored engine tests to ensure that the oil performs according to the claimed specification. Needless to say, such tests are extremely costly to carry out, a full set can cost around $500,000 to run.

The two most prominent specification systems are those of the API (American Petroleum Institute) from North America and the ACEA (Association des Constructeurs Européenne d'Automobile) from Europe. The ACEA system was preceded by the CCMC (Comité des Constructeurs d'Automobiles du Marche Commun). The API system is the original and best-known system and is currently used throughout the world to define engine oil performance requirements

The API designation is based on an alphabetical system, with the letters API being followed by an 'S' (Service) series for passenger car petrol engines, or a 'C' (Commercial) series for diesel engines.

For petrol engines lubricant specifications have advanced from API SA through to the current API SJ, although many vehicle manufacturers may still stipulate the earlier specifications API SH or even API SG in their vehicle handbooks. It is essential that oils of at least the vehicle manufacturer's requirement are used, although higher specification oils should be used in preference to those stipulated in the handbook as soon as they become available, if maximum benefit is to be obtained.

As already indicated, the performance of engine oils has increased dramatically over the years, with each newly-introduced performance level offering significantly improved performance over the previous level.

The original 'SA' category consists virtually of solely base oils, with little or no additive to provide lubricant performance. These were the types of oils used as crankcase lubricants from the time of the invention of the motor car up until around the 1930's, when additives were first used, mainly to improve oxidation stability. In fact the classification 'SA' was never used at the time since the classification system did not come into operation until many years later.

'SA' oils, which do not contain additives, or which contain insufficient levels of additives to be effective, will perform very poorly in practice. Not only will wear rates be drastically increased, shortening the life of the engine, but the rapid formation of sludge and deposits in the engine could result in the eventual blocking of oil-ways, with the possibility of sudden and catastrophic failure.

However, it is a major concern that oils of 'SA' performance level are still readily available, in spite of the fact that modern engines require oils of far higher performance levels. These 'SA' quality oils generally make no performance claims whatsoever on the container, although some lubricant suppliers have claimed an API 'SA' performance level on the container, in an effort to establish some sort of credibility for the product in the eyes of the unknowledgeable motorist.

The years in which successive performance levels came into being are listed below.

| API SERVICE CATEGORY PETROL (Gasoline) | YEAR OF INTRODUCTION | STATUS |
|---|---|---|
| SA (For older engines, no performance requirement. USE ONLY when specifically recommended by the manufacturer) | | Obsolete |
| SB (For older engines. USE ONLY when specifically recommended by the manufacturer) | 1930's | Obsolete |
| SC | 1967 and older engines | Obsolete |
| SD | 1971 and older engines | Obsolete |
| SE | 1979 and older engines | Obsolete |
| SF | 1988 and older engines | Obsolete |
| SG | For model-year 1993 | Obsolete |
| SH (will be discontinued in the API Service Symbol 1st August 1997, except when used in combination with certain C (diesel) categories | Introduced in 1993 | Current |
| SJ | October 1996 | Current |

*Each petrol engine category above exceeds the performance properties of all the previous categories and can be used in place of the lower one. For example, SJ oil can be used for any previous category.*

The comparative table for API diesel specification is shown below: -

| API SERVICE CATEGORY DIESEL (DERV) | YEAR OF INTRODUCTION | STATUS |
|---|---|---|
| CA | 1940's & 1950's | Obsolete |
| CB | 1949 to 1960 | Obsolete |
| CC | Engines introduced in 1961 | Obsolete |
| CD (For certain naturally aspirated and turbocharged engines) | Introduced in 1955 | Obsolete |
| CD-II (two-cycle engines | Introduced in 1987 | Obsolete |
| CE | Introduced in 1987 | Obsolete |
| CF-4 (For high speed four-stroke, naturally aspirated and turbocharged engines) [can be used in place of CE oils | Introduced in 1990 | Current |
| CF (For off-road, indirect-injected and other diesel engines incl. those using fuel with over 0.5% weight sulphur) [can be used in place of CD oils] | Introduced in 1994 | Current |
| CF-2 (For severe duty, two-stroke-cycle engines) [can be used in place of CD-II oils] | Introduced in 1994 | Current |
| CG-4 (For severe duty, four-stroke-cycle engines using fuel with less than 0.5% weight sulphur) [can be used in place of CD, CE and CF-4 oils] | Introduced in 1995 | Current |

API suggests that the consumer should refer to the owner or operator manual for specific vehicle and/or engine manufacturer's engine oil recommendations.

The European situation is more complicated in that the ACEA body is relatively recent, the earlier organisation being CCMC. Therefore manufacturers of new or relatively recent vehicles may stipulate either CCMC specifications or ACEA specifications.

The CCMC categories were described as CCMC G4 or G5 for petrol engines, and CCMC PD2 for passenger car diesel engines or CCMC D4 or D5 for heavy-duty diesel engines. This categorisation system has now been superseded by the ACEA system; the current ACEA specifications being listed in the table below. The different categories within each column reflect differing types of engine requirements.

| PASSENGER CAR PETROL | PASSENGER CAR DIESEL | HEAVY DUTY COMMERCIAL DIESEL |
|---|---|---|
| A1: 98 | B1: 98 | E1: 96 Issue 2 |
| A2: 96 Issue 2 | B2: 98 | E2: 96 Issue 2 |
| A3: 98 | B3: 98 | E3: 96 Issue 2 |
| | B4: 98 | E4: 98 |
| | | E5: 99 |

Performance aspects, which are covered by both API and ACEA specification systems include:

Reduction of friction
Resistance to wear
Resistance to oxidation
Resistance to frothing
Resistance to corrosion
Detergency
Promotion of demulsification
Control of emissions
Compatibility with catalyst systems
Deposit formation
Ring sticking
Fuel economy increases
Polymer compatibility, etc., etc.

As with the viscosity specifications, the performance specifications are displayed on retail packs of motor oil. However, motor oils will generally describe several specifications on the container, since it is normal for a single oil to simultaneously meet a variety of specifications, e.g. API SJ/CF, ACEA A3-98, B3-98. Thus identification of the correct specification is much less clear-cut than in the case of the relatively simple and straightforward viscosity requirement.

Unfortunately, conformance to such performance claims cannot readily be established by simple chemical analysis. Due to the complexities and variations of the different chemistries involved in the additive systems, there is no direct correlation between the chemical composition and the performance aspect of the motor oil.

As already indicated above, there are a number of motor oils currently being marketed which, although being marked with a viscosity classification, do not claim any performance specification whatsoever, but do claim to be motor oils. Some contain dubious markings such as stock codes, which could be mistaken for a specification claim. The viscosity requirement is often brandished in a most prominent manner (e.g. 20W/50), we suspect that the way the products are labelled is an attempt to confuse the customer into believing that the contents are suitable for use in today's vehicles. Many of these products are not at all suitable for use in your prized possession.

This is not a new situation; such oils have been available for many years. However, in the past, such non-specification oils have generally been supplied by reputable manufacturers and have contained sufficient levels of additives to enable them to function reasonably well as motor oils in low to moderate duty applications. They have found favour either with customers who are only concerned with price or have problems with excessive oil consumption.

A comparatively recent development is the appearance of a series of non-specification engine oils available from a number of sources which have insufficient levels of additives to function as a motor oil even under low to moderate duty conditions and are therefore unfit for purpose. Although it has already been established that the performance aspects of a motor oil cannot be exactly established by analysis, it is nevertheless possible to equate performance levels in general terms to elemental content. In the particular oil chemistry used in the examples quoted below, the chemical elements, which are predominant in establishing the lubricant performance, are zinc, calcium and phosphorus respectively. Analysis of a typical sample of an unfit oil also included in the table, clearly shows that the elemental composition is so low that the oil would fall very far short of the performance levels expected of a modern engine oil, being more typical of the sort of engine oil that dates back to the pre-1930's.

| API CATEGORY | YEAR | ZINC ppm | CALCIUM ppm | PHOSPHORUS ppm |
|---|---|---|---|---|
| SA | | 0 | 0 | 0 |
| SB | 1930's | 0 | 0 | 0 |
| | 1940 | 500 | 0 | 400 |
| SC | 1964 | 500 | 1000 | 400 |
| SD | 1968 | 600 | 1000 | 500 |
| SE | 1972 | 600 | 1000 | 500 |
| SF | 1980 | 1000 | 2000 | 900 |
| SG | 1989 | 1000 | 3000 | 1000 |
| SH | 1992 | 1000 | 3000 | 1000 |
| SJ | 1996 | 1000 max | 4000 | 900 |
| SAMPLES OF 'NO-SPEC' OILS | 1997 | 71 | 151 | 72 |

These unfit oils are often available from reputable retailers who in all probability do not have the specialised knowledge to realise the extent of the inadequacy of these products. Whilst appreciating that there may well be a limited market for such oils, e.g. in the case of vehicles with high oil consumption, which are shortly to be scrapped, the sales volumes of these products indicates that the majority are being used inappropriately, i.e. in vehicles which are in generally good order, and whose owners are not aware of the potentially damaging effect of these oils. There is no indication or warning on the pack to its limited suitability, as described above. Use of these oils will result in vastly increased wear rates in the engine and the formation of deposits, which will reduce efficiencies and eventually cause failure.

Unfortunately, since there is a considerable time period between cause and effect, engine damage would not immediately become apparent until some time after a low specification oil was used.

The customer may not associate subsequent engine problems as being linked to the oil which may well have been introduced some time previously.

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LUBE-TECH

# KWIKPOWER'S LUBRICATING OIL TO DIESEL (LOD) FUEL TECHNOLOGY

Kwikpower International, a US fuel technology company with offices in London, Chicago, and Washington DC, is installing the first facility in Europe using their proprietary patented process for the conversion of waste motor and industrial lubricating oils into #2 diesel fuel. The process technology is covered by patent protection in the United States and patents are in the final stages of approval in the EU, as well as a number of other countries.

Kwikpower has just announced that the first of a number of facilities planned will be installed at the site of the former Texaco refinery facility in Ghent, Belgium. The facility is being installed in a Joint Venture with a Belgium partner, and delivery of the plant is scheduled for March, 2000 with operations expected to commence in April/May, 2000.

## PROCESS DESCRIPTION:

Kwikpower's Lube Oil to Diesel process converts waste oils into diesel fuel in a onestep process of thermal cracking and distillation. Thermal cracking converts heavy, long chain hydrocarbon molecules into smaller molecules, which are lighter and more volatile. This is done by applying process heat in an oxygen free environment, achieving temperatures on the order of 700 degrees F. The resulting fuels are then separated out in a conventional distillation column. Each 100 gallons of waste oil processed yields approximately 70 gallons of #2 diesel fuel, 20 gallons of high heat content #4 fuel and the equivalent of 10 gallons of "light ends", mostly gases. The light ends are burned and the heat recaptured for use in the conversion process.

## INDEPENDENT ANALYSIS AND CONFIRMATION

The Lube Oil to Diesel process technology has been under continuous development since mid 1992, and a pilot unit, operating at 7 gallons per hour, was successfully tested and put into operation in January 1993. The first full-scale version was constructed in early 1993. Commercial designs are now complete for the Model 400, 600 and 1000 with Model numbers referring to the number of gallons per hour of end product #2 diesel fuel produced. The systems are manufactured using mostly off-the-shelf refinery quality components, and no difficult manufacturing or assembly process is required.

## TESTING OF PRODUCTS BY INDEPENDENT LABORATORIES

Diesel fuel produced by the process has been independently tested by a number of commercial laboratories, with the results being on spec or higher quality ASTM spec #2 diesel fuel; flash point 154F; cetane 52 or higher; distillation range: 336F-664F, metals less than 1 part per million, and water less than 0.05%.

## TECHNOLOGY ASSESSMENT

W. Tom Jones, Director of Technology-Chemicals & Plastics Division, Fluor Daniels Engineering conducted an independent site inspection and assessment for a third party company, and his comments were as follows: "well constructed, system well thought out, sophisticated but easy to use"; "safety has been a major consideration", "flameless thermal oxidation should make the unit easy to permit", to eliminate coke formation, cracking is limited to about 20% per pass with high tube velocities and controlled heat of 12,000 BTUs across the tub surface and a controlled residence time."

## PERMITTING AND EMISSION TESTING

Emission testing of a typical Model 1000 Lube oil to diesel facility was completed in June 1997 by the independent environmental testing laboratory, DEECO Inc of Cary, N.C., under the direct supervision of EPA and Department of Health and Environmental Control (DHEC) of South Carolina, to allow issue of operating permits for continuous operations using thermal oxidation for process heat and control of emissions.


Above: Thermal oxidizer heat source at Green Oasis Ltd. Partnership LOD plant in Charleston, South Carolina.

The test results obtained were exceptional:

| | | | |
|---|---|---|---|
| Organic Compound Concentration; | test | 1.56 | EPA Limit: 20.00 |
| Organic Compound Emission Rate: | test | 0.0046 | EPA Limit 0.21 |
| Hydrogen Chloride | test | 0.23 | EPA Limit 2.21 |

In June of 1998 the US EPA issued a letter ruling that the lube oil to diesel process does not fall under EPA Subpart NNN (i.e., the facility is not a refinery) since the feed stock processed is not crude oil.

## MARKETS:

World-wide, waste oil generation is estimated at more than 8 billion gallons per year. The EU, and all states in the USA (as well as most other countries) require that used oils be recycled or otherwise properly disposed of. Despite these restrictions, it is estimated that more than 20% of used oil generated is improperly disposed of in landfills or elsewhere, constituting a potentially hazardous waste that is considered a serious environmental problem.

Presently, approximately 1.0 billion gallons of waste motor oil is collected in Europe, and 1.4-1.5 billion gallons of waste motor oil is collected annually in the United States, mostly by small companies. In the past, typically, these waste oils were processed by simply cleaning the oil and remove water using mild heat, with no chemical change in composition, and the resulting product has been burned as Alternative fuel oil in cement kilns, asphalt plants, or power stations. Re-refining processes, which yield a recycled lubricant as opposed to a fuel, are quite capital intensive, operate only at larger scales at high expense, and produce a product which is difficult to market, and is not wanted by the lubricants industry,

## SUMMARY

In summary, Kwikpower's Lube Oil to Diesel technology offers a unique and cost effective solution to the growing world-wide environmental problem of the disposal of waste oils (fossil or synthetic).

The facility is an automated mini-cracking/distillation processing plant, which is patented and fully permitted with an air emission quality of 99.96% pure, which meets all known world-wide permitting and safety requirements.

Kwikpower can be reached in the UK at 44 171 499 1188. Fax: 44 171 499 1188.