GARDNER
Engine Forum

Spring 2025

No. 47

www.gardnerengineforum.co.uk

GARDNER Engine Forum

Membership Application

Title	Mr / Mrs / Miss / Dr / Other		
Forename(s)			
Surname			
Address			
		Post Code	
Telephone No		Ex-Directory	Yes/No
Mobile Telephone Number			
Email Address *			
Engine Model			
Engine Serial No			
Engine Date			
Engine Application	Stationary	Road	Marine
Name of vehicle / vessel			
Any other information			
Signed		Dated	

Periodically we produce a membership list and circulate to members. The list comprises of the membership number, name and address only. To be included in the list and therefore receive a copy please indicate your preference.

Yes please include me ☐ No Thank You ☐

* To keep the cost of running the forum as low as possible we use email communication for the notification of renewal and confirmation of membership where possible. If supplied the email address will not be passed on to any third party and will only be used for communicating matters relating the the Forum.

Membership details are maintained on a computer database accessible to authorised committee members only.

Membership fee £10.00 per annum (UK) renewable on the anniversary of joining.
Payable by cheque, standing order mandate or electronic fund transfer.
Cheque's to be made out to Gardner Engine Forum.
For standing orders please complete the form below.download the compite form from the website

For electronic funds transfer please tick the box, ☐ we will contact you with the banking details

Send the completed form to
Mrs J M Gray - Treasurer.Gardner Engine Forum 29 Verity Walk, Wordsley, Stourbridge, DY8 4XS
Email:- gardnerengineforum@blueyonder.co.uk

Gardner Engine Forum Philosophy

The aims of the Forum are to promote and foster interest in all Gardner engines"

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Knutsford. WA16 7BA
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Free for Members Personnel Ads, Museums, and individuals providing services in support of Gardner Engines

Cover Photo
A delivery of 4LW's
Photo courtesy of the Anson Engine Museum

Chairmans Notes

Welcome to the spring newsletter, the new year as you will be well aware came in very wet and windy. I hope that none of you were affected. In my part of the world, the river Irk reached new heights, with the water level recorded at 1.58M at Colleyhurst weir. Well above the previous record at 1.43M. Is all this clear evidence of the extent to which our climate is rapidly changing.

It is always good to communicate with fellow members of the Forum and even how they became involved with our great engines. Michael related to me how it all started for him, Gardner Engines have always been a big part of his life since starting school! Living in a remote area, he travelled to school by bus and would arrive at the bus stop early to get a good seat at the back (near the heater) and frantically complete his homework, with the Gardner Engine gently ticking over. They were in a different league to other engines. Whilst still at school he had a weekend job working for a local bus and coach operator. His role was to fuel, wash, clean and park the vehicles (at the age of 15). The fleet included several Leyland Leopards, Daimler Fleet Liners and ex South Yorkshire MCW metro buses with Rolls Royce Eagle engines. Everything changed when two ex London Gardner 6LXB powered MCW metro buses joined the fleet. The reliability and fuel economy compared to the other engines was staggering, he couldn't believe the difference. From that moment his interest in Gardner Engines never diminished. Evidently the Gardner powered Olympian were excellent and certainly one of the best chassis he worked on. It was reliable, well engineered and always came home unassisted. His first experience of the Olympian was as a passenger, school buses were a mixture of City of Oxford vehicles, mainly Bristol VRT's and Olympians. Olympians were obviously a huge leap forward from the previous generation of vehicles and the Oxford examples were always well presented. The Olympians enjoyed a long life in the city and were frontline vehicles for many years. The Oxford examples were Gardner/self changing gears driveline, except for one TC11 powered ex demonstrator. The final batch of 6 delivered in 1990 were Gardner 6LXCT/ZF. Michael worked in the bus industry for over twenty years operating many Gardner powered vehicles and as he told me "quote" I am preaching to the converted, but the 6LXB was a legendary bus engine, loved by drivers,engineers and even accountants! Michael many thanks and I hope we will see you at the AGM.

All you canal boaters will be well aware of the Bridgewater breach. I have been following it as it is quite near to me. I well remember the last one in 1971. I think it took two years to repair, how long will it take to repair the latest breach? I hope to see many of you at the AGM in May.

A welcome to new members, Mike Peace, David Davies, Michael Wootton, Graham Daniels, Colin Marsh, Simon & Dawn Trevor Roberts, Steve May.

John

Annual General Meeting

The Forum A.G.M will take place on
Saturday 17th May at 12 o'clock
At the British Commercial Vehicle Museum
King Street
Leyland
PR25 2LE

Museum entry cost will be covered by the Forum
The museum is open from 10 am to 4-30 pm
Refreshments will be provided for anyone attending the meeting.

Items for the agenda should be sent to
Mrs L Kemp
Korna Cottage
Works Lane
Barnstone
NG13 9JJ
or by email to gardnerengineforum@blueyonder.co.uk

Change of date for the 2025 Rally

at

Etruria Industrial Museum
with Shirleys Bone & Flint Mill
Etruria
Stoke on Trent

Saturday 20th & Sunday 21st September

This coincides with the National Heritage weekend.
There will be a Stationary Engine Display on the Saturday and a Classic Car display on the Sunday

If you are planning to join us for the rally at Etruria please note the change of date from the one published in the last newsletter, to the 20th and 21st
We have organised a hog roast for the Saturday evening, this is available to all members and guests attending who wish to take part. We do however need to know how many to cater for, so if you want to join us please fill in the appropriate section on the rally entry form or email gardnerengineforum@blueyonder with your details and the number of places that you would like to reserve. Monies will be collected at the rally.

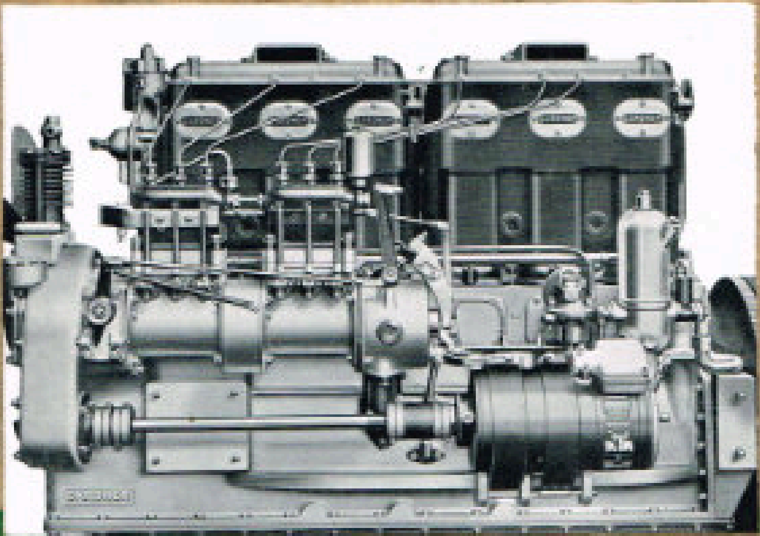
What Oil

The question of what oil should I use in my engine crops up frequently on internet forums, there will then be a flurry of replies advocating the virtues of a particular brand and grade, with no technical reason to back it up. Looking through the manuals for a particular engine isn't very enlightening either. The manual for an L2 simply states that, suitable oils are supplied by any of the well know manufactures and must conform to the following specification of, "Viscosity Redwood No 1 Specification "BW" or "BS" (Winter and Summer)", along with a more detailed list of blend requirements.

No mention of a viscosity number as we would recognise today. As the way in which the viscosity index has changed over the years it is difficult to correlate the early specifications with the current system.

The Wellasline brochure which I believe to be from 1936 expounds the merits of their product and gives some insight into the industry at the time.
As detailed in the second article from the Society of Automobile Engineers (SAE) around 1940, the American military and the different engine manufacturers started to develop better testing methods, which resulted in a new classification system, the earliest being the military specification "MIL-L-2104A". Gardner's included this in its manuals replacing the older "BW-"BS" designations, although instruction book 61.8 for the LX-LXB engines has the pre war and the the military specifications, along with a SAE viscosity range for summer and winter.
The early "MIL-L-2014A" equated to the API designation of "CB". This was replaced by "MIL-L-2014B" which was API "CC", this became obsolete in 1953 being replaced by "MIL-L-2014C", API "CC-CD", eventually in 1992 it became "MIL–L-2014F" which is API "CF." Despite being an obsolete specification since 1953 oils that meet the MIL-L-2014B, API "CC" specification are very widely available today. Perusal of the API chart on page 17 states that oils up to the "CF" specification can be used in naturally aspirated diesel engines. Gardner's instruction book 68.1 for the LX/B/C stipulates that oils above MIL-L-2104B are not approved for naturally aspirated engines although Turbo engines need to use oils to a minimum of MIL-L-2014C, API "CD".

So L2, LW. LX, LXB, LXC, engines should use an oil that meets the "MIL-L-2014B," API "CC" specification with a viscosity index of 30 for summer use (13°C to 32°C).



The Correct Lubrication

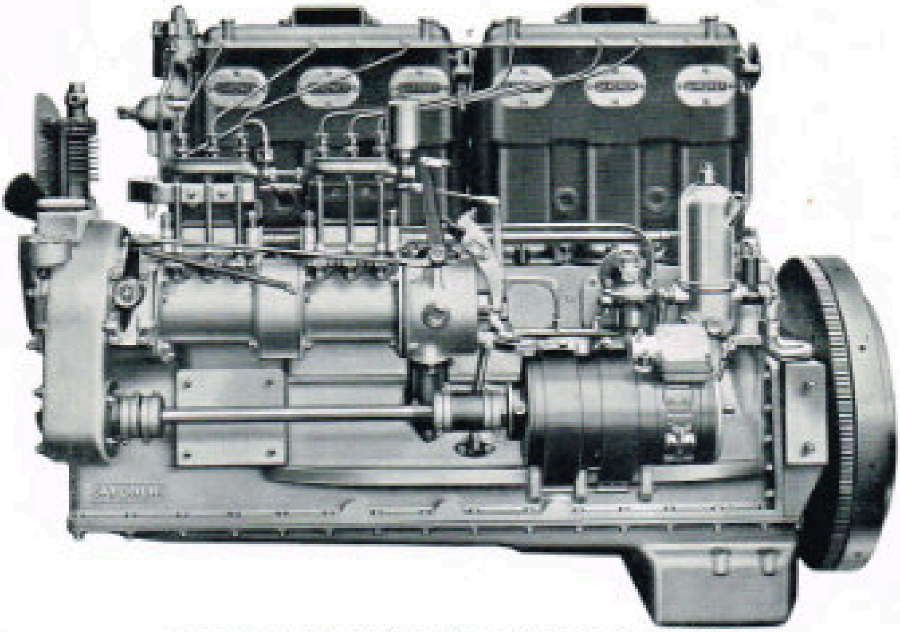
OF

GARDNER ENGINES

Matthew Wells & Co. Ltd.

"WELLSALINE" OIL WORKS, MANCHESTER, 3
ENGLAND

GARDNER ENGINES. No. 1. 730.



"GARDNER" 6LW TYPE HIGH-SPEED HEAVY OIL ENGINE.
For Commercial Chassis, High Speed Passenger Vehicles, Rail-Coaches, and Diesel Locomotives.
Illustrated by courtesy of Messrs. L. Gardner & Sons, Ltd., Patricroft.

The following grades of "Wellsaline" have been approved of by the Makers for the lubrication of this engine:

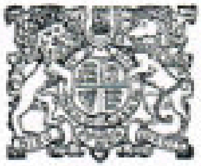
For Summer use and tropical conditions—"Wellsaline" "SDMH" or "Wellsaline" "SFMH."
For Winter use and cold climates—"Wellsaline" "SDA" or "Wellsaline" "SFL."

MATTHEW WELLS & CO.

LIMITED.

"Wellsaline" Oil Works, Manchester, 3, England

Telegrams and Cables: "OILWELLS, Manchester." Telephone: BLAckfriars 0771/0772



By Appointment

Contractors to His Majesty's Government and Large Corporations, Home and Overseas.

London Office: 84, Leadenhall Street, E.C.3.

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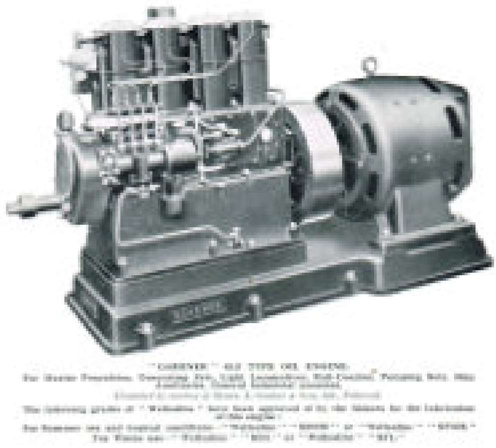
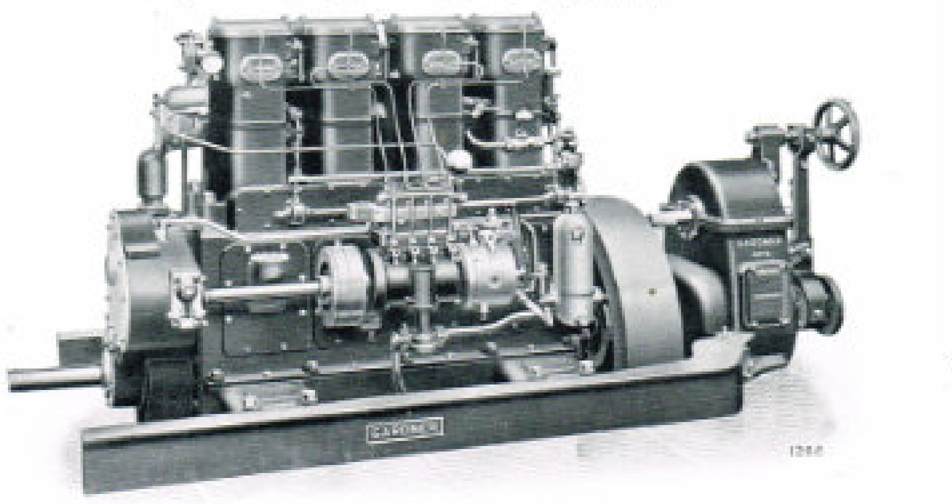
The Correct Lubrication of "Gardner" Heavy Oil Engines

It is several years since our earlier booklet on the lubrication of high speed Heavy Oil Engines was introduced, and in the intervening period we have seen the extraordinarily rapid progress in the commercial development of this type of engine. The main technical problems have been solved; many of them were solved some time ago, but in the interim the motor transport industry has had ample time to study the general reliability, economics, and wearing qualities of this type of power unit, with the result that it has been increasingly widely adopted and there is every indication that at least as regards the heavy transport vehicles, the day of the petrol engine has already passed.

In the past the introduction of heavy oil engines was undoubtedly accelerated by the freedom from taxation of the heavy oils employed on this type of engine. When the taxation of road Diesel engines was brought into line with the taxation of lighter fuels, it was at first thought that this would result in a decrease in the use of this type of engine, but now that the effect of the tax has become fully understood, the indications are that the heavy oil engine will come into more widespread use due to its own inherent virtues, and without any assistance in the form of advantages in respect of fuel taxation. The consumption of fuel per brake horse power hour and consequent consumption of fuel per mile run is very much lower with the heavy oil engine, and fuel taxation actually is to the advantage for this type of power unit, provided it is in competition with other engines, the fuels of which are equally taxed.



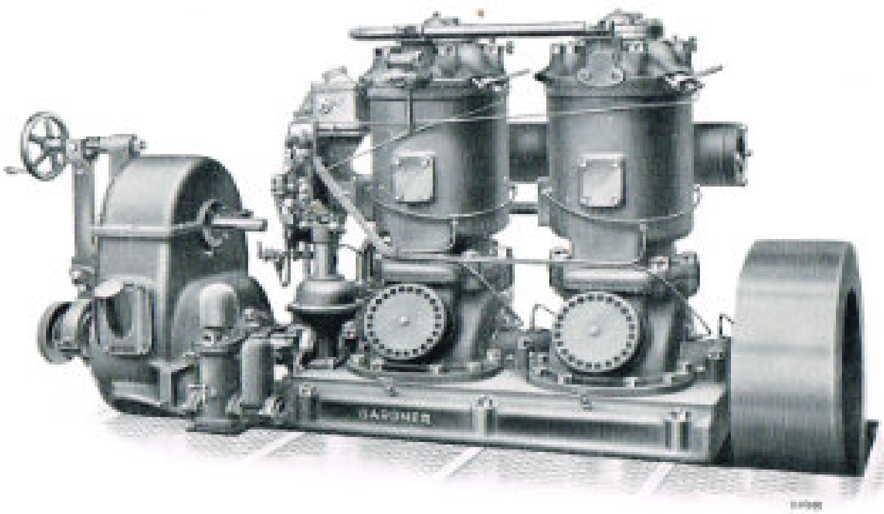
The low consumption of Diesel engines is primarily due to two reasons. Firstly, in engines in which the fuel is absent from the cylinder during the compression stroke, there is no danger of detonation or pre-ignition, and consequently it is possible to employ high compression ratios which allow a higher proportion of the heat generated to be converted into work, and a lower proportion to pass from the engine in the form of hot exhaust gas. The connection between compression ratio and overall efficiency is a mathematical function which applies to all internal combustion engines. The second advantage of the heavy oil engine cycle, is the fact that at low loads are developed by reducing the quantity of fuel injected into the cylinder, and under low load conditions it is not necessary to restrict the quantity of air entering the cylinder. This means that whilst operating at low load the pressure in the cylinder during the suction stroke is not widely removed from the pressure' of the external atmosphere. Now in the petrol engine low loads are obtained by restricting the total amount of explosive mixture entering the cylinder and not by altering the proportion of petrol in the mixture. In actual practice the proportion of petrol in the mixture at low loads is at least as great as that employed at maximum load, in fact many carburettors are so adjusted as to give a slightly richer mixture at low loads. In view of this low load, conditions are obtained by restricting the inlet from the carburettor thereby considerably reducing the pressure of the cylinder during the suction stroke. Whilst this reduces the total mixture; entering the cylinder, it at the same time produces an artificial load on the engine, the engine becoming a pump which is pumping from a partial vacuum into an exhaust system at approximately atmospheric pressure, and to overcome this load a certain amount of the fuel is consumed. Consequently we find that on



"GARDNER" 4L3 TYPE HIGH SPEED HEAVY OIL ENGINE.
For Marine Propulsion, Industrial purposes, Generating Sets, Diesel Locomotives, Rail-Coaches.
Illustrated by courtesy of Messrs. L. Gardner & Sons, Ltd., Patricroft.
The following grades of "Wellsaline" have been approved of by the Makers for the lubrication of these engines:
For Summer use and tropical conditions—"Wellsaline" "SDMH" or "Wellsaline" "SFMH."
For Winter use and cold climates—"Wellsaline" "SDA" or "Wellsaline" "SFL."

low loads the fuel consumption of petrol engines is exceedingly high.
The reason why it is impossible to vary the mixture strength and thereby control load on the petrol engine, is on account of the extremely narrow range of petrol/air mixtures. A weakening of the mixture results in a non-explosive mixture. Rich mixtures may also be non-explosive and the range between a mixture giving economic power output and the weakest mixture which will produce regular firing, is extremely narrow.

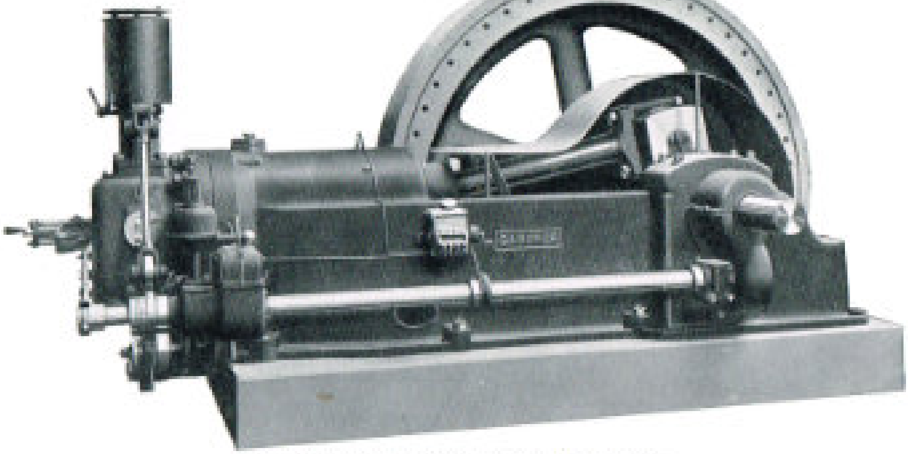
Bearing in mind this explanation for the high fuel consumption of petrol engines



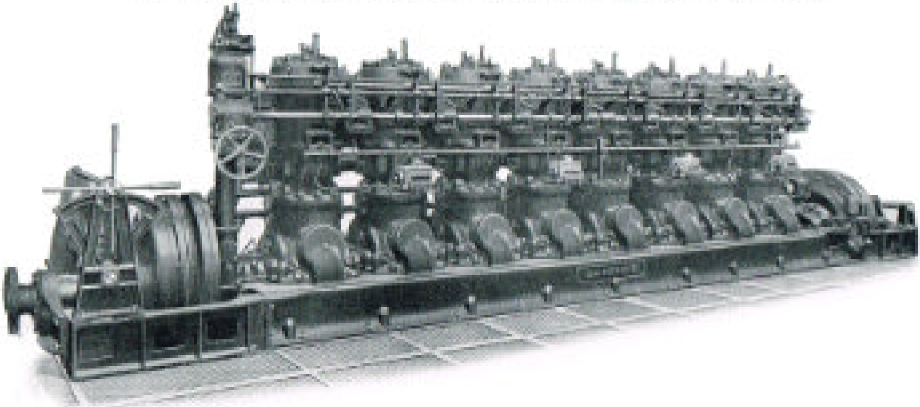
"GARDNER" 2.5 VT TYPE HEAVY OIL ENGINE.
For Marine Propulsion, Marine Auxiliaries, Semiportable and Stationary Power Plant and small Pumping Plant.
Illustrated by courtesy of Messrs. L. Gardner & Sons, Ltd., Patricroft.
The following grades of "Wellsaline" have been approved of by the Makers for the lubrication of this engine:
For Summer use and tropical conditions—"Wellsaline" "SDMH" or "Wellsaline" "SFMH."
For Winter use and cold climates—"Wellsaline" "SDA" or "Wellsaline" "SFL."

on low load, we find that this class of engine is really very ill-suited on economic grounds for operating under conditions of extremely variable load, such as are encountered in road vehicles. The advantage in reduced fuel consumption of the heavy oil engine is more marked when these engines are employed in road vehicles than the marine or air services, where the loads are more constant.

It has also been argued that as the consumption of fuel oil increases and the consumption of petrol decreases, the prices of the two commodities may be



"GARDNER" 14 HF TYPE HEAVY OIL ENGINE.
For Factories and Industrial purposes, and for Electric Generating Sets.
Illustrated by courtesy of Messrs. L. Gardner & Sons, Ltd., Patricroft.
Lubricate with "Wellsaline" "SDMH" or "Wellsaline" "SFMH" Summer and Winter.



"GARDNER" 8J9 TYPE 400 B.H.P. MARINE HEAVY OIL ENGINE.
For Marine Propulsion, Electric Generators, etc.
Illustrated by courtesy of Messrs. L. Gardner & Sons, Ltd., Patricroft.
The following grades of "Wellsaline" have been approved of by the Makers for the lubrication of this engine:
For Summer use and tropical conditions—"Wellsaline" "SDMH" or "Wellsaline" "SFMH."
For Winter use—"Wellsaline" "SDA" or "Wellsaline" "SFL."

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reversed and that fuel oil may become dearer than petrol. Such a state of affairs, however, does not appear probable as a very large proportion of the petrol at present marketed is made from gas oil or fuel oil by the cracking process, and the latter process involves a certain amount of wastage and considerable operating charges, so that as long as cracking is a refinery process the price of petrol must always be substantially higher than that of fuel oil, and it would only become possible for the price of petrol to be lower than fuel oil if the consumption of petrol were decreased to an enormous extent, which would mean the complete conversion of private cars and aeroplanes to the heavy oil engine, a development which, although possible, does not appear probable in the immediate future.

The preliminary difficulties encountered in the design of high speed oil engines were, mainly connected with the design of the combustion space in such a way as to ensure combustion of the fuel in the comparatively small interval of time available, and the design of fuel pumps capable of metering accurately very minute quantities of oil. These problems have been almost entirely solved by special design of the combustion chamber, which has the effect of increasing the period available for combustion and also producing the necessary turbulence to ensure that the major portion of the air is brought in direct contact with the fuel, a point which is of considerable importance in Diesel work, but which does not arise in engines which are fed with fuel in the form of an explosive mixture generated outside the cylinder. No great difficulty has been encountered in designing engines of such mechanical strength as to withstand the higher compression pressures which are a feature of the compression ignition cycle.

It is, however, necessary to have exceptionally well-fitting pistons with tight piston rings and a generally well-made mechanical job; consequently the high speed oil engine is more sensitive to quality of lubrication than the petrol engine. In addition to this it is the general experience that any mechanical device of comparatively recent innovation will not allow the same latitude in quality of lubricant as is permissible in machines where all the problems have been solved by many years of experience of working.

The lubrication problems of the high speed Diesel engine may be considered as a compromise between those encountered in Diesel engine practice and those existing in petrol engines. The lubricant must be capable of forming a very effective piston seal to withstand the high compression and working pressures encountered. It must also be of stable base, so as to minimise any chemical change which may take place in the lubricant during use. It must be sufficiently able to withstand the high temperatures encountered with the minimum amount of decomposition. It must possess sufficient " oiliness " factor to keep the bearing surfaces from coming into contact with each other.

A further property required by this lubricant is that it must be capable of working and still giving satisfaction even when partially contaminated with the fuel oil, which is liable under certain circumstances to pass from the combustion space to the crankcase. In this respect the conditions differ considerably from petrol engine conditions, in that although dilution or contamination of the crankcase is liable to take place in both engines, the fuels which bring about the dilution are of a very different nature.

The firm of Matthew Wells & Co. Ltd. have had very considerable experience in the past of the lubrication of both slow speed and high speed stationary type of Diesel engines. They have also had prolonged experience with the lubrication of petrol engines and have kept in very close touch with research and development work in the period during which high speed oil engines were being developed. This enabled the firm to keep in continuous contact with manufacturers and with users since these engines have come into general use.

As a result of their experience, Matthew Wells & Co. Ltd. have developed two series of lubricants for high speed oil engine work ; the first is the **" Wellsaline " Super Diesel Series,** the grades of which are referred to by the letters **" SD"** and the second is the **" Wellsaline" Super-Filtered Series**, the grades of which are referred to by the letters " **SF**." In each series there are five oils, viz.: Light, Medium, Medium Heavy, Heavy and Extra Heavy.

There is only a slight difference in quality between the two series, the main advantage of the " SD " (Super Diesel) series being the extraordinary flatness of the viscosity-temperature curve; in other respects the oils are almost identical. The members of the " SF" (Super-Filtered) series are less expensive, owing to their being refined from a crude which is more readily available.

The claims which Matthew Wells & Co. Ltd. put forward for both these oils are as follows

(1) They possess the necessary " oiliness " factor to withstand the bearing pressures encountered,and to minimise the possibilities of piston seizure, or running out of bearings, even though the engines might be operating under adverse conditions such as bad alignment, or some contortion of the mechanical parts.Even under extreme conditions of load both series of oils can be relied upon to give perfect lubrication.

(2) Both series are capable of with standing the amount of contamination which is liable to take place in normal circumstances of running with high speed oil engines, whether the fuel employed is a gas oil or a residual oil.

(3) The corresponding members of both series are of approximately the same viscosity at average working temperature, and all the oils can be relied upon to make an effective gas seal at the piston rings, thus preventing blow past and its consequent dangers.

(4) In both cases the bases are of extreme stability, that is to say, the chemical nature of the oil is such that though exposed in the crankcase of the engine and cylinder walls to the action of air and exhaust gases for prolonged periods, the oil will not become oxidised. Inferior oils are very liable to thicken up, become sticky, and form carbon deposits after prolonged periods of use.

This latter property is by far the most important property of a lubricant as the"oiliness" factor is sufficiently high in even the poorest quality lubricant to meet the requirements of a reasonably well-designed engine.

The selection of the correct viscosity is only a matter of experience, and very inferior oils may often possess the right viscosity for use. The difference between a really good oil for this service and an inferior oil, therefore, resolves itself almost entirely to a matter of stability, that is to say, an inferior oil will give perfectly good running on practically any engine when it first goes into service, but the weakness of inferior oils is their liability to form gums, carbon and sticky deposits which are liable to clog up the lubrication system, and at the best, will create dirty engines, while under adverse circumstances inferior oils may so clog up the lubricating ducts as to cause failure of the oil supply with consequent serious injury to the engine. The question of stability, therefore, is a matter of primary importance in lubrication.

The bases of both these series possess exceptional chemical stability, and will withstand the engine conditions for prolonged periods without undergoing appreciable chemical and physical change.

Both the " SD " and " SF " series have extremely flat viscosity-temperature curves. The phenomenon of flatness of viscosity-temperature curve is the property of undergoing a minimum change in viscosity over a given period of temperature. All oils on heating become considerably thinner, but with some oils this thinning out, or reduction in viscosity, is much more marked than with other oils. " Wellsaline " oils maintain their viscosity extremely well at high temperatures, and consequently it is possible to use an oil which, though comparatively "thin" at normal temperatures, still possesses enough " body " or viscosity to give satisfactory operation at the highest temperatures encountered in engines. There is a considerable advantage in the lubricant possessing such properties, as the

use of a free-flowing oil at normal temperature is a great advantage in that it facilitates starting, ensures easy running and satisfactory power production in the period during which the engine is warming up. Free running during this period results in it being possible for the engine to carry its load at shorter notice, and also reduces the total fuel consumption.
Oil refiners have realised the importance of flatness of viscosity curve, and during recent years a system of classification of lubricants according to the inclination of the viscosity-temperature graph has become almost universal in the refining industry. The basis for this system of classification is somewhat complex, but briefly, it is a mathematical formula by which the average inclination of the curve may be rated in certain numbers, and any oil can therefore be classed as possessing a certain rate of change of viscosity with change of temperature, the figure so obtained being known as the viscosity “index” of an oil.

An oil possessing a flat viscosity curve is therefore known as an oil of high viscosity index, whilst an oil with a steep viscosity curve, i.e., rapid fall of viscosity with increase of temperature, possesses a. low viscosity index. Both series of the oils put forward by Matthew Wells & Co. Ltd. possess high viscosity indices, but the " SD " (Super Diesel) series are slightly superior in this respect.

Both series possess low freezing points, so that in practice no difficulties may be encountered by partial solidification of the oils whatever the weather conditions may be. In all these properties they will compare favourably with any products on the market at the present time.

Our technical knowledge of the refining of lubricants has greatly advanced during recent years, and the materials available for the manufacture of the finished lubricants are undergoing continuous improvement. During the last few years the more effective removal of paraffin has been made possible by developments in the technique of refining, whilst the resistance of oils to oxidation has been undergoing continuous improvement for years past due to the employment of new processes for the removal of unstable constituents, such processes are capable of improving the quality of oil produced from both the highest and the lowest qualities of Crude, but the advisability of employing the highest quality of Crude still remains where lubricants of extremely high performance are required. We claim that we are in continuous touch with all improvements, and that our products are the result of the employment of the most modern practice in refining operations, together with that practical knowledge which can only be gained by experience. It is the combination of these which has resulted in the introduction of these special lubricants for heavy oil engines as specially designed for transport purposes.

The following chart gives the correct oil for various types of Gardner and similar engines as used on Road Transport Vehicles, Tractors, Diesel Locomotives, Road Rollers, Generating Sets, Marine Propulsion, Industrial Purposes, Rail-Coaches, etc., etc.

“Wellsaline” "SD" (Super Diesel) Series and “Wellsaline” "SF (Super-Filtered) Series are both listed, and the two oils are interchangeable.

We advise clients to adhere strictly to this list unless they have special reasons for doing otherwise. The only exceptional cases are in extremely heavily worn engines running under overload, where in some cases it is advisable to use an oil one grade heavier than the normal recommendation. It is better, however, when considering such a procedure, to communicate with the suppliers, who are always pleased to provide technical information to clients.

"WELLSALINE" RECOMMENDATION CHART
For Gardner Engines
which comply in every respect with the Makers' specification and have been tested and approved of by Messrs. Gardner.
To guide users on these points the following table of relative viscosities has been compiled. All the grades mentioned will mix perfectly with each other.

The approved oils for “LK” engines for use in average temperature conditions are “Wellsaline” “SDA” or “Wellsaline” “SFL” as above, to Gardner's specification " BW."

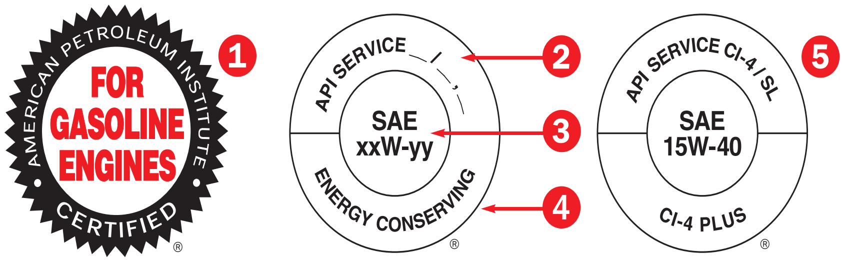
Relative Viscosity at 200° F.	To Gardner specification “BS” for use in Summer or in warm climates :-	
66	**D.13**	**“Wellsaline” “SDMH”**
	D21	**“Wellsaline” “SFMH”**

Relative Viscosity at 200° F.	To Gardner specification “BW” for use in Winter or in cold climates :-	
56	**D.8**	**“Wellsaline” “SDA”**
	D3	**“Wellsaline” “SFL”**

Relative Viscosity at 200° F.	To Gardner specification “KW” for use in Winter or in cold climates , especially for “LK” engines:-	
54		**“Wellsaline” “SDKW”**
		“Wellsaline” “SFKW”

AMERICAN PETROLEUM INSTITUTE

MOTOR OIL GUIDE



API® Certification Mark "Starburst" | API® Service Symbol "Donut" | API® Service Symbol "Donut" with CI-4 PLUS

API's Service Symbol and Certification Mark identify quality engine oils for gasoline- and diesel-powered vehicles. Oils displaying these marks meet performance requirements set by U.S. and international vehicle and engine manufacturers and the lubricant industry. More than 500 companies worldwide participate in this voluntary program, which is backed by a marketplace sampling and testing program.

1. Starburst: An oil displaying this mark meets the current engine protection standard and fuel economy requirements of the International Lubricant Standardization and Approval Committee (ILSAC), a joint effort of U.S. and Japanese automobile manufacturers. Most automobile manufacturers recommend oils that carry the API Certification Mark.

2. Performance Level:
Gasoline engine oil categories (for cars, vans, and light trucks with gasoline engines): Oils designed for gasoline-engine service fall under API's "S" (**S**ervice) categories. See reverse for descriptions of current and obsolete API service categories.

Diesel engine oil categories (for heavy-duty trucks and vehicles with diesel engines): Oils designed for diesel-engine service fall under API's "C" (**C**ommercial) categories. See reverse for descriptions of current and obsolete API service categories.

3. Viscosity Grade: The measure of an oil's thickness and ability to flow at certain temperatures. Vehicle requirements may vary. Follow your vehicle manufacturer's recommendations on SAE oil viscosity grade.

4. Energy Conserving: The "Energy Conserving" designation applies to oils intended for gasoline-engine cars, vans, and light trucks. Widespread use of "Energy Conserving" oils may result in an overall savings of fuel in the vehicle fleet as a whole.

5. CI-4 PLUS: Used in conjunction with API CI-4, the "CI-4 PLUS" designation identifies oils formulated to provide a higher level of protection against soot-related viscosity increase and viscosity loss due to shear in diesel engines. Like Energy Conserving, CI-4 PLUS appears in the lower portion of the API Service Symbol "Donut."

GUIDE TO SAE VISCOSITY GRADES OF MOTOR OIL FOR PASSENGER CARS

Multigrade oils such as SAE 5W-30 and 10W-30 are widely used because, under all but extremely hot or cold conditions, they are thin enough to flow at low temperatures and thick enough to perform satisfactorily at high temperatures. **Note that vehicle requirements may vary. Follow your vehicle manufacturer's recommendations on SAE oil viscosity grade.**

If lowest expected outdoor temperature is	Typical SAE Viscosity Grades for Passenger Cars
0°C (32°F)	5W-20, 5W-30, 10W-30, 10W-40, 20W-50
−18°C (0°F)	5W-20, 5W-30, 10W-30, 10W-40
Below −18°C (0°F)	5W-20, 5W-30

GUIDELINES TO HELP YOU GET MORE FROM YOUR MOTOR OIL

- Refer to your owner's manual for type of oil to use.
- Follow manufacturer's oil change recommendations.
- Use only the recommended API category: "**S**" for gasoline engines; "**C**" for diesel engines.
- Select the proper SAE oil viscosity grade.
- If you find it necessary to mix brands of oil, use the same viscosity grade and API service category to maintain performance.
- Properly dispose of used oil. Learn more about recycling used oil on the web at www.recycleoil.org. Go to www.earth911.org for used oil collection center locations.

Look for the API Quality Marks every time you buy motor oil.

Ask for API-licensed oil whenever you have your oil changed.

For more information about API's Engine Oil Program, visit our website at www.api.org/eolcs.

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American Petroleum Institute

AMERICAN PETROLEUM INSTITUTE

MOTOR OIL GUIDE

Which oil is right for you?

The current and previous API Service Categories are listed below. Vehicle owners should refer to their owner's manuals before consulting these charts. Oils may have more than one performance level.

For automotive gasoline engines, the latest engine oil service category includes the performance properties of each earlier category. If an automotive owner's manual calls for an API SJ or SL oil, an API SM oil will provide full protection. For diesel engines, the latest category usually – but not always – includes the performance properties of an earlier category.

Gasoline Engines

Category	Status	Service
SM	Current	For all automotive engines currently in use. Introduced November 30, 2004, SM oils are designed to provide improved oxidation resistance, improved deposit protection, better wear protection, and better low-temperature performance over the life of the oil. Some SM oils may also meet the latest ILSAC specification and/or qualify as Energy Conserving.
SL	Current	For 2004 and older automotive engines.
SJ	Current	For 2001 and older automotive engines.
SH	Obsolete	For 1996 and older engines. Valid when preceded by current C categories.
SG	Obsolete	For 1993 and older engines.
SF	Obsolete	For 1988 and older engines.
SE	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1979.
SD	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1971. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SC	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1967. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SB	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1963. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SA	Obsolete	CAUTION—Contains no additives. Not suitable for use in gasoline-powered automotive engines built after 1930. Use in modern engines may cause unsatisfactory engine performance or equipment harm.

Note: API intentionally omitted "SI" and "SK" from the sequence of categories. For more information about API's Engine Oil Program, visit our website at www.api.org/eolcs.

Diesel Engines

Category	Status	Service
CI-4	Current	Introduced in 2002. For high-speed, four-stroke engines designed to meet 2004 exhaust emission standards implemented in 2002. CI-4 oils are formulated to sustain engine durability where exhaust gas recirculation (EGR) is used and are intended for use with diesel fuels ranging in sulfur content up to 0.5% weight. Can be used in place of CD, CE, CF-4, CG-4, and CH-4 oils. Some CI-4 oils may also qualify for the CI-4 PLUS designation.
CH-4	Current	Introduced in 1998. For high-speed, four-stroke engines designed to meet 1998 exhaust emission standards. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulfur content up to 0.5% weight. Can be used in place of CD, CE, CF-4, and CG-4 oils.
CG-4	Current	Introduced in 1995. For severe duty, high-speed, four-stroke engines using fuel with less than 0.5% weight sulfur. CG-4 oils are required for engines meeting 1994 emission standards. Can be used in place of CD, CE, and CF-4 oils.
CF-4	Current	Introduced in 1990. For high-speed, four-stroke, naturally aspirated and turbocharged engines. Can be used in place of CD and CE oils.
CF-2	Current	Introduced in 1994. For severe duty, two-stroke-cycle engines. Can be used in place of CD-II oils.
CF	Current	Introduced in 1994. For off-road, indirect-injected and other diesel engines including those using fuel with over 0.5% weight sulfur. Can be used in place of CD oils.
CE	Obsolete	Introduced in 1985. For high-speed, four-stroke, naturally aspirated and turbocharged engines. Can be used in place of CC and CD oils.
CD-II	Obsolete	Introduced in 1985. For two-stroke cycle engines.
CD	Obsolete	Introduced in 1955. For certain naturally aspirated and turbocharged engines.
CC	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1990.
CB	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1961.
CA	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1959.

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American Petroleum Institute

History of Automotive Lubrication.

Today's lubricant quality is defined by classifications or specifications, that are established by taking into account metallurgy, equipment design, and or operating conditions for engine oils, the American Petroleum Institute (API). the Society of Automobile Engineers (SAE), and the American Society for Testing and Materials (ASTM) are the key bodies that define Industry needs, establish classifications, and develop test methods to assure that lubricants meet the required performance. For gear oils API and the Coordinating Research Council (CRC) play a similar role. The U.S. military and original equipment manufacturers (OEMS) have their own performance requirements that are usually over and above those of the API/SAE/ASTM and API/CRC. The performance requirements of automatic transmission fluids (ATFs) are established by OEMs, such as General Motors Corporation (GM) and the Ford Motor Company, Greases are defined by the National Lubricating Grease institute’s (NLGl) classification system. The paper follows the history of automotive lubrication from the early 1900s to date. It describes the introduction and specifications with changes in the lubricating environment.

Introduction

All mechanical equipment must be lubricated. The purpose is to reduce friction and wear. If not controlled, these can lead to inefficiencies, damage, and ultimately to equipment seizure.
Pictorial records depicting the use of lubricants date as far back as 1050 B.C. Analysis of the residue from chariot axle hubs suggests the use of animal fat as a lubricant as early as 1400 B.C. This practice continued until 1859 When petroleum-based lubricants became available. Most modern lubricants are petroleum based although vegetable oils and animal fats are also used. All lubricants contain chemicals called additives', without their presence, effective lubrication of modern machinery is not possible. Common types of automotive lubricants include engine oils, transmission fluids, gear oils and greases. Lubricant performance is generally defined by viscosity and service conditions, that evolve with changes in hardware, equipment design and operating conditions.

Engine Oils

Engine oils are designed to reduce friction, minimise deposit formation, and prevent corrosion and wear. The quality of these oils is defined by SAE viscosity classifications, the API service classification system, and the specifications established by the US. Military and the OEM's.

Viscosity Classifications

Viscosity is one of the most important properties of a lubricant. It can be defined as a lubricants resistance to flow. Proper viscosity in a lubricant minimises surface-to-surface contact, hence friction and wear. The importance of viscosity was recognised in the earlier part of this century (20^{th}) when, in 1911, SAE established the first engine oil classification system based on viscosity. The 1923 revision included specifications for 10 oils that were classed according to their viscosity ranges. The specification numbers ranged from 20 to 115 and were based on the first two digits of the average Saybolt viscosity in seconds (SUS). The numbers between 20 and 50 we based on viscosity at 100'F and the numbers between 60 and 116 were based on viscosity at 210'F. Two special specifications, 020 and 030, were assigned to oils with Pour points ≤10W. This classification was of limited use because marketing and owners manufactures designations of "Light", "Medium", etc did not properly fit its viscosity grades. Hence, in 1926 a classification system based on viscosities at 130°F and 210°F was established where the classification numbers had no direct relation to actual viscosities.

In 1933, the Lubricants Division tentatively introduced two W grades where viscosity at 0°F was determined by extrapolation from higher temperatures. In 1950, SAE grades 10, 60, 70 and the 130°F requirements were dropped. A new grade 5W was added and l0W and 20W were officially included in the classification. Multi-viscocity grades became part of the classification in 1955, and the classification became official in 1962 as SAE J300. In 1967, the cold cranking method to determine 0°F viscosity of the W grades replaced the extrapolation method, and kinematic viscosity to measure 210°F viscosity became a primary method, In 1967 and 1974, additions were made to the classification without changing the number of viscosity grades, However, in 1975, a new grade 15W was added. There have been several revisions since.

Multi-grade oils are an outcome of the development of viscosity modifiers in the early 1950s. These are made by dissolving polymeric materials to low viscosity, or thin, oils. These materials thicken oil more at high temperatures than at low temperatures. Hence, at low temperatures, oil flows easily due to its inherent low viscosity. But at high temperatures, its flow is resisted because of the thickening effect of the polymer. The invent of viscosity modifiers eliminated the need to use oils for Summer and Winter operation and allowed the use of one oil for all seasons

Gasoline Engine Oil Classifications

Until 1947, the performance of engine oils was defined solely by their viscosity grades, without due consideration to engine design, its operating environments, and fuel type and quality. In 1947 API introduced three performance categories, regular, premium, and heavy-duty, based on severity of service. The regular oils were straight mineral oils with or without viscosity modifiers and corresponded to oils defined previously by the viscosity grades. These oils were for both gasoline and diesel engines operating under mild to moderate service conditions. The premium oils, designed for somewhat more severe operating conditions, generally contained oxidation and corrosion inhibitors and in some cases mild detergents. The heavy-duty oils possessed better oxidation and corrosion resistance and detergency than premium oils and were designed to withstand the most severe service.

Although a great improvement over that before 1947, this system did not distinguish oils based on fuel type. Therefore introduced separate performances for gasoline and diesel engine oils. The gasoline engine oils were as specified as ML, MM, DS. The first letters M & D stood for motor oil and diesel engine oils, G stood for general use with no exceptionally severe requirements, M for moderate severe service and S for exceptionally severe service.

The severity of service is a function of engine design and can vary across engine types, fuel characteristics, and operating conditions. MS type service was considered typical of gasoline and other spark-ignition engines that required protection against deposits, wear, and corrosion. This type of service is considered most severe because it includes both short trips (stop and go driving) and continuous driving at high speeds and at at high loads (freeway and turnpikes). Short trips promote oil screen and oil ring clogging, varnish deposits especially on hydraulic valve lifters and sludge formation in the crankcase and oil filters. They also lead to corrosive wear or rusting of critical engine parts such as cylinders, piston rings, and shafts, and to dilution of the oil by unburned fuel. Freeway operation promotes oxidation of lubricating oil which may lead to high-temperature varnish and sludge deposits and scuffing, and corrosion of some types of bearing.

In order to define oil quality for gasoline engines, a series of sequence tests were adopted by the API. Sequence 1 and ll investigated low temperature medium speed scuffing and wear and low temperature deposit formation and rusting. Sequence ll was a high temperature oxidation test. 1958 Oldsmobile engine was used for all three. Sequence IV investigated high temperature high speed scuffing and wear using a DeSoto engine. Sequence V test assess an oil's tendency to form insolubles and sludge and could use either a 1957 Lincoln engine or a CLR single cylinder. Revisions to this this system occurred in1955, 1960 and 1968. API collaborated with SAE and ASTM to install a new system of classifications that not only related to previous categories but also the ability to provide new categories in the future. The classification had four categories SA to SD where "S" stands for service. Subsequently other categories were added to parallel changes in lubrication environment as a result of changes in engine design, operating conditions, and testing conditions. The performance requirements of these categories are based on standard tests.

The API service symbol "Donut" established in 1983 communicates the engine oil's quality and performance to the general public. It helps in the selection of oils that meet manufacturers recommendations for use in the intended application. The upper part of the the symbol displays the API service category, the centre part displays the SAE viscosity grade and the bottom part displays the energy conserving feature if applicable. Oils that achieve a minimum 1.5% reduction in fuel use relative to a reference oil are labelled as Energy Conserving I (EC-1) and those providing 2.7% reduction or over are labelled as (EC-ll). Only licensees are authorised to display this symbol. Of the categories listed in the API Classification System (SA to SH), only SH is active. Others are obsolete.

The International Lubricant Standardisation and Approval Committee (ILSAC) a collaboration of the American Automobile Manufacturers Association and the Japan Automobile Manufacturers Association, have introduced their own performance categories. GF-1 and GF-2. these categories, issued In 1992 and 1996, use the API SH performance criteria but include a fuel economy sequence V1 lest. The field testing is only required for technologies that are radically different from those in existence. The API plans to Introduce a new category, SJ before year's end. Its performance requirements essentially parallel those for ILSAC GF2 with added performance required by Japanese OEM/s. ILSAC GF-2 with added performance required by Japanese OEM/s, ILSAC GF3 to be introduced by year 2000, replaces the present L-38 test run on leaded fuel with that run on unleaded fuel. In addition, Sequence lID is replaced with a Ball Rust Test, Sequence IIIE is replaced with Sequence llF, and Sequence VE is replaced with VG. Nissan KA 24E is proposed to evaluate low temperature valve train wear. These changes are implemented to include test engines of current design and operating on unleaded fuel to conform with the growing trend towards the use of unleaded gasoline. The requirements of the obsolete categories are satisfied by API SH, ILSAC GF-1, and ILSAC GF-2 which are designed for the most severe operation. Gasoline engine oil categories along with the engine test requirements are given in Table 2. The time-line is depicted in Exhibit 1. Note that Caterpillar 1 H and 1H2 Diesel engine tests, required for SD and SG, are not included in other categories, possibly because the combination categories, such as SF/CD and SH/CE, include a 1G or 1G2 Diesel engine test.

Heavy-duty Diesel Engine Oil Classifications

Compression Ignition or Diesel engines used before the second world war were large and slow-speed and were easy to lubricate. During and after the second war, the need for fast-running engines led to the development of engines of compact but complex design. This placed a heavy demand on the lubricants. Besides the SAE viscosity classification system, there were no established performance criteria and the end user had to depend on lubricant suppliers claims of the suitability of lubricants. As a consequence, OEMs started to introduce their own performance specifications. The Ingersoll-Rand company in 1931 was one of the first.

1. **Military Specifications**: The lubricant quality gained national importance during the war years and a great deal of work was done to develop and test lubricants. In 1945, Caterpillar Tractor Company, which was involved in developing new Diesel engines, collaborated with GM and, based on testing, listed a number of oils for their equipment. The U.S. Military selected oils from this list for its use

In 1941, the Army specification 2I04 was issued. The Coordinating Research Council (CRC), established in 1943, help devise the first military specification, M1L-L-2104A it originally consisted of five tests, CRC L1 to L5. The L1 test, of 480 hrs duration, evaluated lubricant performance in terms of ring sticking, wear, and deposits. The L2 test, a 20w min long cycling test. Evaluated accelerated running in of the engine. Both tests used a single cylinder Caterpillar Diesel engine. The L3 tests designed to determine the stability of oil and its tendency to corrode copper-lead bearing was 120 hours long and used a 4 cylinder Diesel engine. The L.4 test a 36 hr test, used a 6 cylinder gasoline engine to determine oxidation characteristics of heavy-duty crankcase oils. The L-5 test, a 500 hr test, used a 2-stroke 3 or 4 cylinder Diesel engine to determine oxidation, ring sticking, detergency, and silver bearing characteristics of the oil.

After gaining experience, all tests except L-1 and L-4 were dropped. This led to military specification 2104B in 1949, in 1950, the military specification MIL-0-2104 replaced specification 2104B by taking into account fuel quality.

Caterpillar observed that MIL-0-2104 specified oils did not provide optimal performance in applications that Involved lightly run and or heavily loaded engines using high sulphur fuels. High wear and poor performance were observed. The engine temperature was not high enough to evaporate water which led to corrosion and not low enough to prevent ring sticking. The oils that performed well in the LI test with 1% sulphur fuel were called Supplement 1 oils and those that withstood both high sulphur and high temperatures as a consequence of super-charging were called Supplement 2 oils.

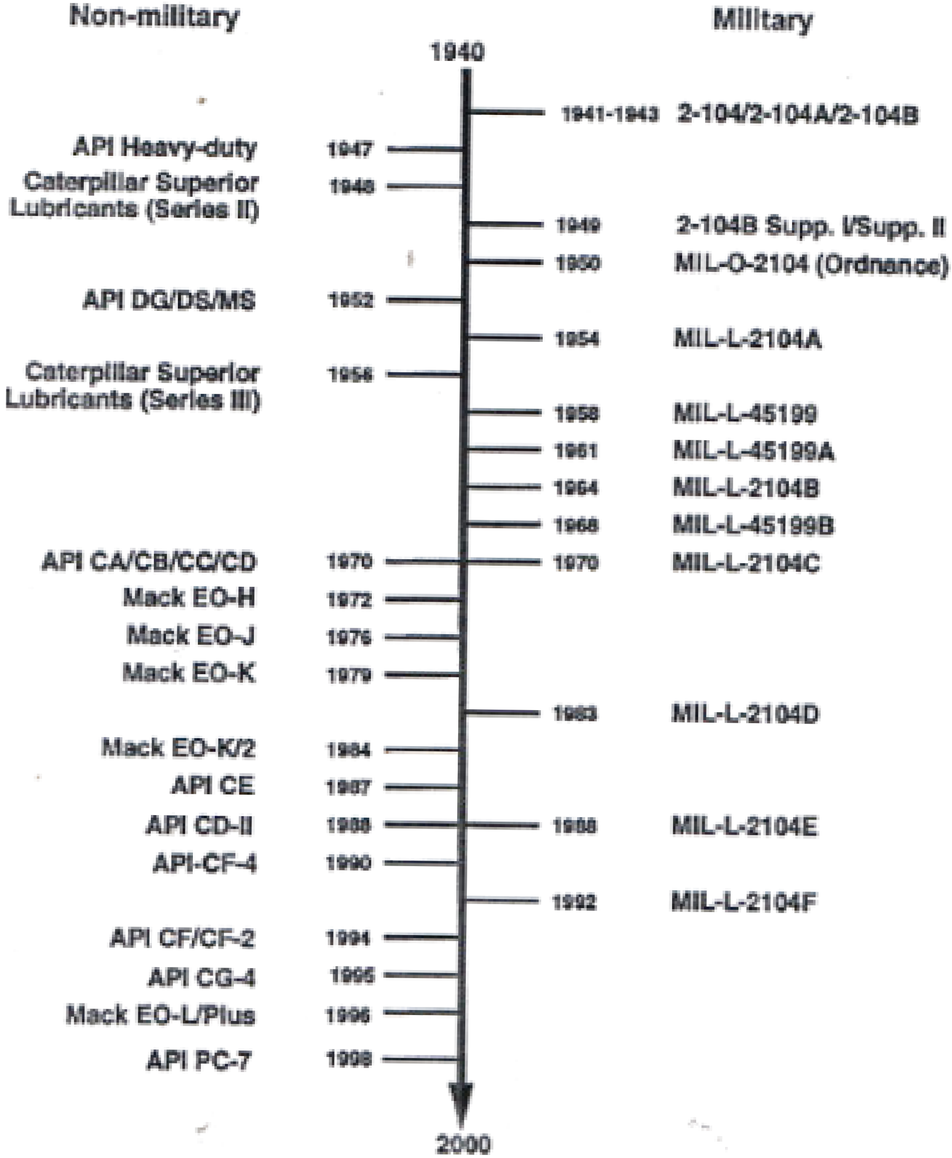
In 1954 the US. Military adopted Supplement 1 oils in its MIL-L-2104A specification. The L4 test engine became unavailable, hence the test was replaced with the CRC L-38 test. This test became part of the performance requirements of the MIL-L=45199A specification in 1961 and of the MIL-L-2104B specification in 1964. The MIL-L-45199A replaced the MIL-L-45199 specification of 1958 that was meant for oils for high output Diesel engines and was based on Caterpillar Series 3 Lubricant requirements, MIL-L-2104B fulfilled the lubrication requirements of both supercharged and unsupercharged engines. The L-38 test, still in use, is a 40-hr test that uses a Labeco CLR single cylinder engine operating on leaded gasoline. It, like its predecessor, evaluates a lubricant's resistance to oxidation, as reflected by its viscosity change, and its sludge and varnish forming and bearing corroding tendencies. The specification MIL-L-2104C of 1970 resulted from the merging of MIL-L-45199A and MIL-L-2104C as it qualified oils in general heavy duty use. This specification in addition to standard tests (L-38 and Caterpillar 1G or 1G2) including gasoline sequence tests in the D and E versions of Mil-L-2014 Mack and Detroit Diesel engine tests and Caterpillar and Allison friction tests were included. The inclusion of the friction tests made these oils suitable for use in transmissions also. The MIL-2014F introduced in 1991 is the most recent of the military specifications.

TABLE 3: ENGINE OIL CLASSIFICATION SYSTEM FOR COMMERCIAL DIESEL ENGINE SERVICE

"C" — SERVICE OILS (Fleets, Contractors, Farmers, Etc.)			
API Automotive Gasoline Engine Service Categories	Previous API Engine Service Categories	Related Industry Definitions	Engine Test Requirements
CA	DG	MIL-L-2104A	CRC L-38 Caterpillar L-1* (0.4% sulfur fuel)
CB	DM	Inhibited oil only	CRC L-38 Caterpillar L-1* (0.4% sulfur fuel)
CC	DM	MIL-L-2104A Supplement 1	CRC L-38 Sequence IID Caterpillar 1H2*
CD	DS	MIL-L-2104B MIL-L-46152B	CRC L-38 Caterpillar 1G2
CD-II	None	MIL-L-45199B, Series 3 MIL-L-2104C/D/E	CRC L-38 Caterpillar 1G2 Detroit Diesel 6V53T
CE	None	None	CRC L-38 Caterpillar 1G2 Cummins NTC-400 Mack T-6 Mack T-7
CF-4	None	None	CRC L-38 Cummins NTC-400 Mack T-6 Mack T-7 Caterpillar 1K
CF-2	None	None	CRC L-38 Caterpillar 1M-PC Detroit Diesel 6V92TA
CF	None	None	CRC L-38 Caterpillar 1M-PC
CG-4		None	CRC L-38 Sequence IIIE GM 6.2L Mack T-8 Caterpillar 1N
PC-7	None	None	CRC L-38 Caterpillar 1K Caterpillar 1P Cummins M11 Mack T-8 Mack T-9 GM 6.5L

* *The test is obsolete; engine parts, test fuel, or reference oils are no longer generally available, or test is no longer monitored by the test developer or ASTM.*

OIL SPECIFICATIONS



The Caterpillar engine test similarly evolved over the years. The L-1 engine test using a 208 in^3 (3.4 Lt). The test 481 hr long was run at an engine speed of 1000 rpm. It evaluated a lubricant's ability to control lacquer, deposit formation and wear. In 1948 it was replaced by 1D test that used a supercharged engine. In addition the speed of the engine was increased to 1200 rpm. The 1G test established in 1958 used a downsized 134 in^3 (2.2 Lt) engine operating at an even faster speed of 1800 rpm. In 1956 Caterpillar introduced Superior Lubricants (Series 3) to eliminate field problems of supercharged engines. These lubricants were required to pass Caterpillar 1G to 1G2 around 1976. The test duration for these tests is 480 hours. The 1K, 1N and 1P are the most recent of the Caterpillar single cylinder engine tests. Of these, 1K and 1N are 252 hr duration. 1P is still under development.

API Classification System

This classification for commercial or "C" oils for Diesel engines resulted from the collaboration of the API/ASTM/SAE in 1969/1970. Originally CA to CD were introduced. Over the years new categories were added to meet the changing lubrication needs of engines due to changes in design and or operating conditions. At present the categories range from CA to CG-4, of these all except CF, CF-2, CF-4 and CG-4 of these are now obsolete. A new category PC-7 is under consideration for introduction in 1998.

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