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CIMAC

GUIDELINES FOR DIESEL ENGINES LUBRICATION

LUBRICATION OF LARGE HIGH SPEED DIESEL ENGINES

The International Council on Combustion Engines

Conseil International des Machines à Combustion

CIMAC is an international organisation, founded in 1950 by a French initiative to promote technical and scientific knowledge in the field of internal combustion engines (piston engines and gas turbines). This is achieved by the organisation of congresses and working groups.

It is supported by engine manufacturers, engine users, technical universitites, research institutes, component suppliers, fuel and lubricating oil suppliers and several other interested parties.

The National Member Associations and previous CIMAC Recommendations still available are listed in the back of this publication.

This document has been elaborated by the CIMAC Working Group „Marine Lubricants“ and approved by CIMAC in January, 2001.

FOREWORD BY THE PRESIDENT

CIMAC is in the unique position to draw from the expertise pool of the foremost experts worldwide in the field of combustion engines, to man the CIMAC Working Groups and formulate the CIMAC Recommendations.

It is important to note that CIMAC Recommendations serve not only to consolidate the knowledge and experience, but are also aimed to be of practical importance for engine users, manufacturers and related equipment suppliers.

This present Recommendation on "Lubrication of large high speed diesel engines" is one further result of the deliberations of the CIMAC Working Group No. 8 "Lubricants". This very productive Working Group with its able chairman Jean-Francois Chapuy and efficient secretary K. C. Lim and a very wide participation of experts from various countries, has succeeded over the years in addressing competently a broad thematic spectrum. This was achieved by adopting a sub-Group structure to tackle specific subjects and then consider the results in plenary sessions, in the process of formulating recommendations.

I would like to express my appreciation to the Working Group No. 8 "Lubricants" for yet another significant achievement in completing this present Recommendation, which I believe will be useful for the industry and engine users all over world.

Nikolaos P. Kyrtatos

January 2002

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PREFACE

These guidelines are intended as a summary of the main lubrication features of **large, high speed trunk piston diesel engines** operating on distillate fuels and are different from those described for medium speed engines *(Reference (1)).* Excluded from these guidelines are engines typically operated on residual fuels or that operate in modes of on-highway, commercial road transportation.

1. INTRODUCTION

The large high speed trunk piston engine operates at greater piston speeds than the typical medium speed diesel engines and burns distillate fuels in preference to the cheaper heavy fuel oils. They also in general have higher specific power outputs, higher combustion pressures and exhaust temperatures.

Because of the nature of the applications (marine, off-highway and power generation) in which large high speed engines are used, smaller oil sump volumes are seen with wet sumps being the most common type of installation. This contrasts with the large separate oil tanks and dry sump systems used with the larger, slower medium speed engines. Consequently, the typical stresses imposed on the lubricant by these higher specific output, higher speed engines tend to be greater. This leads to differences in the selection criteria for the lubricants and in the lubrication regime.

2. ENGINES

Large high speed engines can be categorised by:

Bore size, mm
Engine speed, rpm
Mean piston speed, m/s
BMEP (Brake Mean Effective Pressure), bar
P max, bar

For comparison purposes between engines of different size, design and manufacture it is convenient to use two factors:

a) **the power factor** --- defined as, the power developed per piston divided by the cross sectional area (kW/cm^2);
b) **the load factor** --- defined as, the BMEP multiplied by the mean piston speed (bar x m/s)

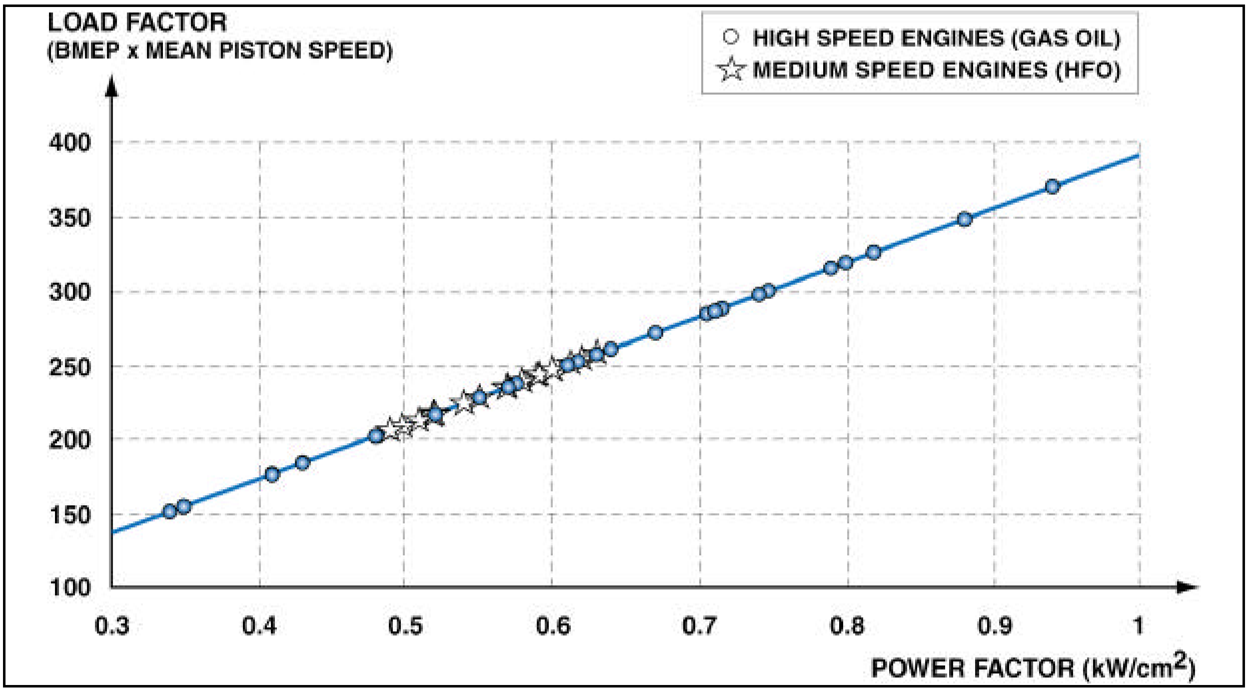
A plot of these two factors for a wide range of engines is given in **Figure 1** to illustrate the range of values. Typical minimum values which define the large high speed diesel engine in these guidelines are 0.5 kW/cm^2 and 210 bar x m/s and the typical parameters for a modern engine are:

Bore	-	> 150 mm
Rotational speed	-	> 1000 rpm
Mean piston speed	-	> 10 m/s
BMEP	-	> 21 bar
Power factor	-	0.5 - 0.9 kW/cm^2
Load factor	-	140 - 375 bar x m/s

Note: Minimum values of load and power factor for typical engines take into account lower loaded larger bore engines as well as very high speed lower pressure engines.

One design trend of significance is the fitting of flame rings or anti-polish bands to minimise piston crown-land deposits. Engines which incorporate such a design tend to have reduced oil consumption which in turn increases the stress on the lubricant.

Figure 1: Large High Speed Diesel Engine Operating Factors



3. FUEL

The ISO 8217:1996 specification defines four types of fuels covered by the generic term 'marine distillates', namely DMX (gas oil), DMA (gas oil), DMB (diesel oil) and DMC (blended diesel oil).

Certain engine types may also operate on automotive gas oils (AGO) which differ from gas oils specified in ISO 8217 with respect to distillation range, additive treatments and to the levels of sulphur permitted within the country of origin. These fuels are generally designated according to National specifications, for example ASTM D-396-96 in N. America or DIN EN-590 within Europe.

4. INSTALLATIONS

Typical installations for the engines are in coastal and inland marine vessels, fast ferries, power generation, or off-highway transportation. The detailed propulsion or generator systems and operating environments vary as indicated.

Application	Speed range	Power conversion	Driver
Coastal or inland marine	Variable speed Constant speed	Gearbox Diesel electric	Propeller Propeller
High speed ferries (mono or multi-hull)	Variable speed	Direct drive Gearbox	Water jet Water jet

The engines also are used in a variety of land-based applications, of which the main ones include :

Application	Conditions
Power generation	Standby, peak shaving, main generation, combined heat and power (CHP)
Railroad	Diesel electric AC or DC systems Diesel Hydraulic
Mining / Earth Moving	Diesel electric, Diesel hydraulic Fluid flywheel.

5. DUTY CYCLES

Service demands may be severe, as indicated by the following maximum parameters:

Load	Cyclic, between idle and full load (100% MCR), even occasional overload
Exhaust temperatures	500 - 650 °C before turbocharger
Service	High service hours per annum
Cyclic operation	Start-stop cycles, with possible heat soak effects

6. LUBRICATION SYSTEMS

6.1 <u>Lubricant Stresses</u>

Such duty cycles place considerable demands upon the lubricant. The engines under consideration generally employ wet sumps, for reduced installation space and weight, which results in smaller oil charge volumes, even though the power densities (kW/m^3) are high. Also, the OEM (Original Equipment Manufacturer) will aim to achieve low specific lubricant consumption values, again to save installation storage space for top up oil.

The combination of high load and power factors, severe duty cycles, low oil sump volumes and low oil consumption gives rise to very high oil stress levels. Stress levels have been defined mathematically by an oil stress factor (OSF) which has units of kWh/g. OSF relates to engine power, oil consumption, oil drain interval and target oil life. *References (2) and (3).*

As a consequence of the high stress values to which the lubricant may be exposed, the oil charge tends to degrade, and does not attain a condition of equilibrium, typical of many large medium speed engine installations. Mandatory oil changes will be necessary, either because the oil reaches condemning limits or has attained the maximum oil drain interval recommended by the OEM. This practice is similar to that of commercial road transport diesel engines. With the constraints on space and weight for many of the applications of large high speed diesel engines, the oil separation or cleaning systems are simple in comparison to those described for medium speed engines.

The typical range of specific oil sump volumes, oil consumption rates and parameters that influence the life of the lubricant are:

Parameters	Value
Specific sump volume	small @ 0.1 - 0.5 kg/kW
Oil Consumption	low @ 0.05 - 0.5 g/kWh
Oil stress	Greater than 2.5 kWh/g
Oil Change interval	Mandatory drain interval (in most cases) Equilibrium conditions established as the exception

6.2 <u>Lubricant Condition</u>

The higher stresses imposed on the lubricant in these engines gives rise to increased insolubles levels from the combustion soot and oxidised oil. In general it is this contamination that may well determine the oil drain interval. A rise in the level of insolubles is one indication of oxidation of the oil which is also usually accompanied by an increase in viscosity. Also BN depletion may occur dependent upon the sulphur level of the fuel. General warning and condemning limits for lubricating oils in large, high speed diesel engines are given in Table 1 (Section 9).

Removal of insolubles from the lubricant in high speed engines with wet sump configurations is achieved either by barrier media filtration and/or by self-powered centrifugal oil cleaners. Occasionally a small motor driven centrifugal separator may be used if space is available but rarely will there be provision for a dedicated centrifuge (or purifier) system as seen on large medium speed engines. Additionally oils designed to cope with higher levels of soot are recommended by engine manufacturers. Such oils contain relatively high levels of dispersants, which have the function of keeping the soot finely in suspension in the oil, and as such may reduce the performance of cartridge filters, centrifugal filters or centrifuges.

Many high speed engine manufacturers are using, or make provision for, a by-pass self-powered centrifugal oil cleaner on their engines. These devices have become more important in recent years with extended oil drain intervals and the introduction of full-flow filters or screens that no longer remove the smaller insolubles from the oil. Self-powered centrifugal oil cleaners are most efficiently operated using hot, high pressure oil supplied directly from the oil pump. The size of self-powered centrifugal oil cleaner needed is determined from the sump size and oil drain period required. Attention must be paid to the operating capacity of the oil pump.

Oil supply pressures and oil back pressure determine the flow rate and rotational speed for the self-powered centrifugal oil cleaners. Changes in rotational speed and/or flow rates caused by sludge build up in the filter screens reduces the efficiency of centrifugal oil cleaners.

Alternatively, the installation of full flow filters with depth filtration technology will protect the engine from oil contaminants. One disadvantage is that full flow filters may become blocked by the sludge collected in them. When this emergency case occurs, the oil filter must be by-passed to avoid danger of oil starvation, and the filters must be changed urgently at next opportunity to avoid damage to engine by unfiltered particles.

To allow continual operation, the option of an automatic back flushing filter using surface filtration technology may be considered. Here the particles are flushed away from the filtration surface after a pre defined interval

Sludge production is the limiting factor for the lifetime of the lubricating oil and disposable filters. This is accelerated by the requirements for better emissions control causing more soot to enter the crankcase oil from the combustion chamber.

In summary, oil cleaning is achieved by the following routes -

Full flow	Barrier media filter or self-cleaning screen
By-pass	Self-powered centrifugal oil cleaner or barrier media filter, or small motor driven centrifugal separator
Combination	Combination of full flow and by-pass

If the oil is cleaned, the following effects are obtained :

Prolonged service life of the oil
Better performance of the oil in the engine
Reduced engine wear from small particles
Less deposit on internal surfaces, resulting in less wear and better cooling.

There are several options to clean the oil which are outlined below:

The traditional method is to use paper cartridge filters with potential blockage and environmentally unacceptable disposal routes
Centrifugal filters are used for removing dense particles such as soot in the sub-micron range and above.
Centrifuges have higher removal rates than conventional centrifugal filters. Independent centrifugal separators are preferable for large engines.

7. LUBRICANT PERFORMANCE

Several critical factors determine the quality and performance criteria of the lubricants for large high speed diesel engines. The combined effects of high load factors, severe duty cycles, small oil volumes and low oil consumption reduce oil life, reduce the oil drain intervals and may not provide adequate protection. Consequently one major criterion for oil selection is its response to the total stress imposed by the engine.

It is essential to ensure lubricant performance in the following principal areas :

Extended oil life, subject to oil drain interval (ODI), and specific oil consumption rates.
Thermal stability and low volatility to minimise oil consumption via base oil loss.
Oxidative inhibition, to resist degradation within combustion chamber and sump.
Deposit control, especially on piston crown lands (to minimise bore polish if anti-polish bands are not fitted) and piston undercrown (to maintain design heat transfer rates)

Insolubles retention until oil change or removal in a centrifugal filter with or without disc stack (centrifuge).
Viscosity to be controlled within prescribed limits
Wear and corrosion protection of bearings especially Al/Sn, Cu/Pb

Engine manufacturers approve or qualify lubricants on proven performance by three main routes:

- The first is the assessment of oil performance in accordance with customary marine or land base practice, namely proof of quality via extensive field/service trials.
- The second, similar to that in the commercial road transport environment, adopts the lubricant specifications defined either by the (API) American Petroleum Institute or European Automobile Manufacturers' Association (ACEA), to determine oil qualities appropriate to the engines in question.

Both these routes can lead to mono-grade oils (SAE 30 & 40), blended from mineral base stocks or multi-grade oils, blended from either mineral and/or synthetic base fluid stocks, that meet technical targets in a wide variety of different bench and engine tests.

- The third is when OEMs combine these routes, by specifying lubricants both on their performance categories (specification driven) and on proven field performance in the OEM engine(s). This practice reflects a degree of uncertainty that tests based on small, high speed truck engines can adequately predict the eventual performance of lubricants in very much larger and more powerful engines. **Figure 2** illustrates the overlap between oil specifications and performance demands.

Engine Rating and Lubricant Specifications ---- Fig 2.

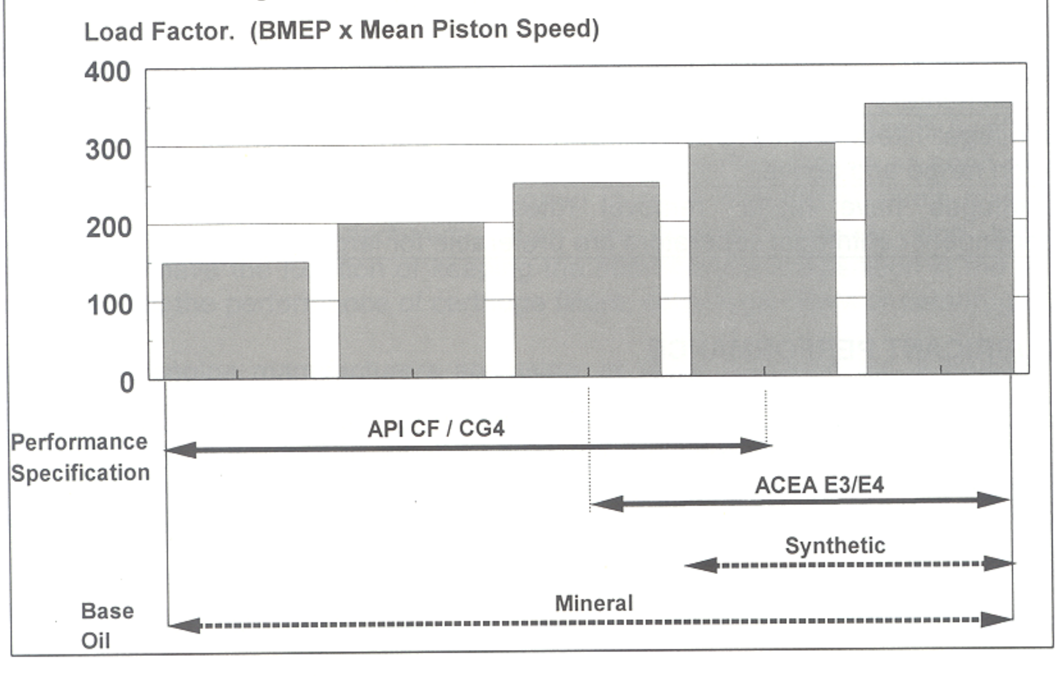
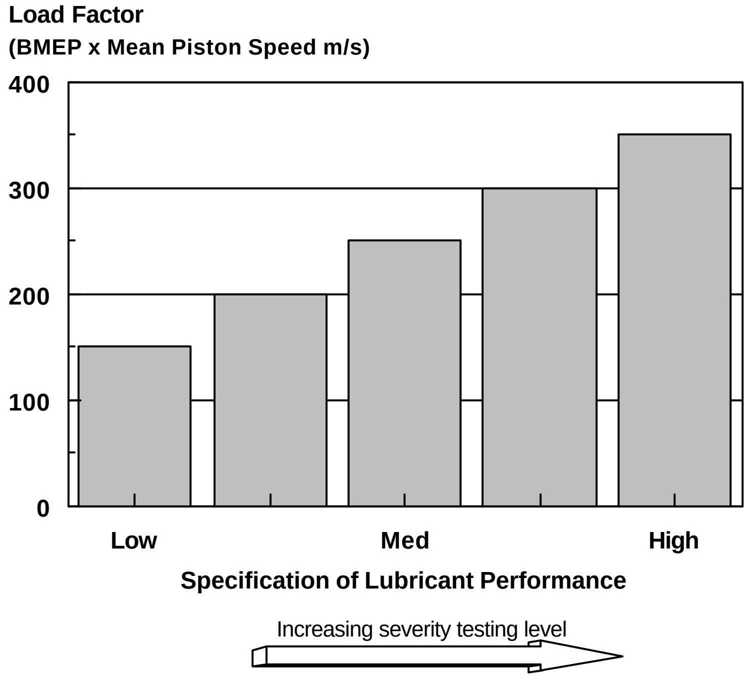
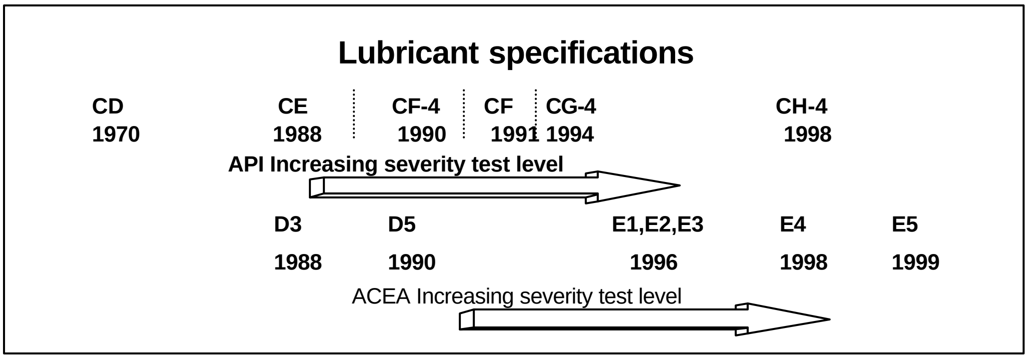


Figure 3 illustrates the lubricant specifications in common use and an outline of the engine tests used to qualify a lubricant

Lubricant Requirements, Specifications and Engine Tests ---- Fig 3.





API Engine Tests	**Measurement**
Caterpillar 1M PC	Piston deposits, wear
Caterpillar 1K	Piston deposits, oil consumption
Caterpillar 1N	Piston deposits, oil consumption
Cummins NTC 400	Piston deposits, oil consumption, wear
Mack T-8	Oil thickening

ACEA Engine tests	Measurements
Mack T8	Oil thickening, soot loading,filter plugging
OM 364A	Sludge, wear, bore polish oil consumption
MB OM 602A	Sludge, deposits, wear, bore polish, oil consumption
MB OM 441LA	Piston deposits, wear, bore polish, sludge, oil consumption

The more recent diesel engine oil classifications have progressively increased soot dispersancy which hold more soot and contaminants in finer particle size. The amount of dispersant in the oil will only support a given level of soot before soot agglomeration into larger particles occurs resulting in increased measured insolubles and viscosity increases. The effectiveness of cartridge filters, centrifugal filters and particularly centrifuges is influenced by particle size and oil viscosity which in turn is influenced by the dispersancy of the oil. Exact performance of filters and centrifuges with different classification of oils should be referred to the equipment manufacturer.

By way of example soot dispersancy differences between the more recent API multigrade oils can be generalised typically as :-

CF4 < CG4 (higher soot dispersancy) < CH4 (even higher)

8. LUBRICANT SELECTION

The selection of a lubricant for a specific application has to be based on the following criteria:

Essential

- Approved by the OEM and/or meets the OEM specification.
- Provides performance up to the minimum recommended oil drain interval based on the duty cycle

Advisory

- Grade advised by lubricant supplier
- Consideration of overall lubrication costs.

9. LUBRICANT QUALITY MONITORING / USED OIL ANALYSIS

Whether or not oil is changed on a fixed time basis, regular oil analysis is recommended in order to monitor the lubricant condition and its continuing use in service. It can also be used to monitor some aspects of engine condition and in particular wear of metallic components in contact with the lubricant.

The following guidelines are proposed:

Take regular oil samples, at OEM specified intervals,
Apply standard methods, if necessary *(Reference(4)),* and/or rapid analytical methods for trend interpretations (not to be based on single parameters or single samples)
Observe limits on critical parameters set by OEMs - in particular, insolubles, changes in viscosity, base number depletion, wear etc
Elemental contamination, oxidation and nitration assessed by oil condition analysis. *(Reference (5))*
Generate data to relate oil condition in service to the probability of deposit formation in critical areas, e.g. piston undercrown deposits becoming critical

Table 1 lists advisory / mandatory action limits for used oil analyses, adapted from *References (1) and (5).*

Table 1 : Advisory / mandatory action limits for used oil analyses

Property	Method	Advisory	Mandatory
Viscosity 40 °C	ISO 3104	-20% / +25%	-25% / +30%
Viscosity 100 °C	ISO 3104	-20% / +20%	-25% / +25%
Flash point, PMCC, °C	ISO 2719	< 190	< 180
Total insolubles, %m #	IP 316	2.0 - 3.0	> 3.0
BN, mg KOH/g	ISO 3771	< 60% of fresh oil	< 50% of fresh oil
TAN, mg KOH/g	ASTM D 664	> new oil + 1.5	> new oil + 3
Water, %v/v	ISO 3733	> 0.2	> 0.3
Oxidation, abs/cm	FTIR	> 15	> 25
Nitration, abs/cm	FTIR	> 15	> 25
Wear elements [mg/kg]	ASTM D 5185 (ICP-PES)	OEM to advise on elements and limits	OEM to advise on elements and limits

Alternative test methods are also often employed *(Reference 1)*

10. GLOSSARY

ACEA	Association des Constructeurs Europeens de l'Automobile (Association of European Automotive manufacturers)
Acidity	In lubricants, acidity denotes the presence of acidic constituents whose concentration is usually defined in terms of an acid number.
Additives	A chemical compound or compounds added to a lubricating oil for the purpose of imparting new properties or enhancing existing properties.
API	American Petroleum Institute
Ash	Some additives, particularly conventional detergent additives, leave behind a powdery residue after combustion. This residue is known as ash and can cause engine malfunction if allowed to build up in the combustion chamber, cylinder liner ports and turbochargers.
Ash (Sulphated)	The ash content of an oil, determined by charring the oil and breaking the residue with sulphuric acid and evaporating to dryness. Expressed as % by mass.
Base Number	A measure of the amount of acid-neutralising additive present in a lubricating oil, also known as Total Base Number.
Base Stock (Base Oil)	Refined petroleum oil used in the production of lubricants and other products. The base stock may be used alone or blended with other base stocks and/or additives, to manufacture a finished lubricant.
Blow-by	Passage of combustion gases past the piston rings of internal combustion engines, resulting in contamination of the crankcase oil.
Carbon Residue	Coked material remaining after an oil has been exposed to high temperatures under controlled conditions. Carbon residue is thus an indicator of the coke forming tendencies of an oil. It can be expressed as Conradson, Ramsbottom or Micro-Carbon Residue (MCR).
Centipoise (cP)	See **Poise**
Centistoke (cSt)	See **Stoke**
Cetane Index	A measure of the ignition quality of a distillate fuel, that is the relative ease with which the fuel will ignite when injected into a compression - ignition engine. Cetane Index is calculated from the API gravity and the mid boiling point of the fuel. High Cetane Indices indicate shorter ignition lags and are associated with better combustion performances.
Cetane Number	Similar to Cetane Index but is derived from a standard engine test rather than by calculation.
Crown	The top of the piston of an internal combustion engine above the firing ring which is exposed to direct flame impingement.
Detergent	A substance added to a lubricant to keep engine parts clean. In engine oil formulations, the detergents most commonly used are metallic soaps with a reserve of basicity to neutralise acids formed during combustion.
Differential Infrared Spectroscopy (DIR)	Method to compare fresh and used oils by showing different peaks at different wavelengths. Used to determine deterioration of engine oils with reference to oxidation, and nitration. See **FTIR.**
Dilution of Engine Oil	Contamination of crankcase oil by unburnt fuel leading to reduced viscosity and flash point.
Dispersant	An additive designed to disperse oil insoluble sludge in suspension, thus preventing harmful deposition in oilways.
Engine Deposits	Accumulations of sludge, varnish and carbonaceous residues due to blow-by of unburned and partially burned fuel, or from partial breakdown of the crankcase lubricant. Water from condensation of combustion products, carbon, residues from fuel or lubricating oil additives, dust and metal particles also contribute.
Engine Test	Use of an internal combustion engine to evaluate lubricants. Parameters such as piston ring groove fill, piston varnish, component wear, oil viscosity etc. are measured.
Flash Point	The temperature to which a combustible liquid must be heated to give off sufficient vapour to form a momentarily flammable mixture with air when ignited under specified conditions.

FTIR	**F**ourier **T**ransformation of **I**nfra**R**ed spectroscopy. Digital generation of spectral information. See **DIR.**
Gas Oil	A petroleum distillate having a viscosity and distillation range between those of kerosene and light lubricating oil. The distillation range of gas oils usually extends from 200°C to 380°C. Gas oil is used as a fuel in medium and high speed diesel engines and as a burner fuel in heating installations.
ICP (or PES)	Inductively Coupled Plasma Emission Spectrochemical Analysis. A method for detecting metal elements in oil at ppm level by using plasma emissions
Insolubles	Contaminants found in used oils due to dust, dirt, wear particles, combustion products (soot) and/or oxidation products often measured as pentane or benzene insolubles to reflect insoluble character.
Kinematic Viscosity	Measure of a fluid's resistance to flow under gravity at a specific temperature (usually 40°C or 100°C)
Lands	The vertical surfaces of the piston crown and the areas between the piston rings.
Liner Lacquers	Hard resin like lacquers that are formed on the surface of liners filling the honing grooves. such lacquers lead to increased oil consumption.
MCR	Maximum continuous rating. The rating at which the manufacturer sets for operation at 100% loading
Mineral Oil	Oil derived from mineral sources, notably petroleum.
Multigrade	'Multigrade' is a term used to describe an oil for which the viscosity/temperature characteristics are such that its low temperature and high temperature viscosities fall within the limits of two different SAE numbers.
Nitration	The process whereby nitrogen oxides attack petroleum fluids at high temperature, often resulting in viscosity increase and deposit formation.
Oxidation	A process by which oxygen combines with a material (eg oil), to form another substance.
Oxidation Inhibitor	An additive which slows down the rate of oxidation of an oil.
Oxidation Stability	A measure of resistance of a product to deterioration through exposure to air.
Poise (P)	The standard unit of dynamic viscosity, usually quoted as centipoise (cP).
Polishing (Bore)	Excessive smoothing out of the surface finish of the cylinder bore or cylinder liner in an engine to a mirror-like appearance, resulting in depreciation of the ring sealing efficiency and adhesion of the oil to the liner surface, leading to high oil consumption. Bore polishing can be produced by excessive quantities of combustion products which build up on the piston lands and rub on the liner, or by ring scuffing.
Rings	The circular metallic elements that ride in the grooves of a piston and provide compression sealing during combustion. Also used to spread oil for lubrication of the cylinder liners.
Ring Sticking	The situation when the piston grooves become sufficiently full of deposits or covered with lacquer to prevent the piston rings from moving freely.
Scuffing	Abnormal wear occurring in engines due to localised welding and fracture. It can be prevented through the use of antiwear, extreme pressure and friction modifier additives.
Semi-synthetic	Blend of mineral and synthetic base oils
Shear Stability	The property of resisting physical change under high rates of shear when applied to a Viscosity Index Improver. It is the ability of the VI improver molecules to withstand breakdown into smaller molecules.
Sludge	Oil insoluble products formed from lubricants and/or fuels used in internal combustion engines, and deposited on engine parts other than those in contact with the combustion space.
Stoke (St)	The unit of kinematic viscosity, ie, the measurement of a fluid's resistance to flow defined by the ratio of the fluid's dynamic viscosity to its density; usually quoted as centistokes (cSt).
Trunk Piston Diesel Engine	Medium-Speed, or High-speed, diesel engine generally using the same oil for both cylinder and crankcase lubrication, and utilising connecting rods to transmit piston power directly to the crankshaft rather than through a crosshead.

Turbocharger	Compressor driven by exhaust gas driven turbine supplying air at higher pressure to the engine to increase power.
Viscosity	That property of a liquid by virtue of which it offers resistance to motion or flow. It is commonly regarded as the 'thickness' of the liquid. Viscosity decreases with increasing temperature.
Viscosity Index (VI)	An arbitrary scale used to measure a fluid's change of viscosity with temperature.
Viscosity Index Improver	An additive employed to raise the VI of a mineral oil and other products.
Zinc (ZDP)	Commonly used name for zinc dithiophosphate, an antiwear/oxidation inhibitor chemical.

11. REFERENCES

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[3] CIMAC Congress Paper D 9.03, A model for lubricant stress in modern diesel engines and its verification in a Wärtsilä 4L20 laboratory engine, Copenhagen,1998

[4] CEC Code of Practice L-47-M-97, Recommended standard methods for the analysis of used oil from large diesel engines, Brussels, 1997

[5] CIMAC Recommendation No.19, 2000 – "Recommendation for the Lubrication of Gas Engines".

12. ACKNOWLEDGEMENT

By endorsing this document, CIMAC acknowledges the work accomplished by the CIMAC Working Group "Lubricants" through its worldwide membership. A detailed listing of participating companies, institutions and associations is given on the inside of the back cover.

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Other CIMAC Recommendations (Prices exclude packaging and postage!)

No. 1	Recommendations for Diesel Engine Acceptance Tests, 1968	Out of Print
No. 2	Recommendations for Gas Turbine Acceptance Test, 1968	Out of Print
No. 3	Recommendations of Measurement for the Overall Noise of Reciprocating Engines, 1970	Out of Print
No. 4	Recommendations for SI Units for Diesel Engines and Gas Turbines, 1975	Out of Print
No. 5	Recommendations for Supercharged Diesel Engines, 1971 Part I: Engine De-rating on Account of Ambient Conditions Part II: Engine Acceptance Tests	Out of Print
No. 6	Lexicon on Combustion Engines, Technical Terms of the IC Engine and Gas Turbine Industries, 1977	Out of Print
No. 7	Recommendations regarding Liability - Assured Properties, Publications and Fuels for Diesel Engines, 1985	€ 13.00
No. 8	Recommendations regarding Requirements for Heavy Fuels for Diesel Engines, 1986 (superseded by No. 11)	€ 13.00
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No.16	Guidelines for operation and/or maintenance contracts, 1999	€ 6.00
No. 17	Guidelines for Diesel Engines lubrication - Oil consumption of Medium Speed Diesel Engines	€ 6.00
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