

HOW TO READ A CAN OF OIL . . . AND HOW THE STUFF INSIDE WORKS

by John S. Evans, B.Sc.



John Evans

When purchasing a can, drum or tankerful of oil, how do you know what you are buying, where you can use it and what sort of quality you are getting for your money?

On every can of lubricating oil there are (or should be) a series of numbers and letters that describe what is inside. This article will look at what those numbers and letters tell you.

Oils have both physical and chemical properties. They consist of a 'base stock' which is refined crude oil blended with various 'chemicals' that impart desired properties to the lubricant enabling it to perform its job. Let's look at the physical properties first.

THE PHYSICAL PROPERTIES OF OIL

The most important physical property of an oil is its viscosity. Viscosity is defined as a fluid's resistance to flow, under gravity, at a specified temperature. What that simply means is: 'how thick is the oil?' Thick oils do not flow so easily and have high viscosities, thin oils are quite fluid and have low viscosities. Think how differently transmission fluids behave when poured compared to gear oils. The actual property of interest is called kinematic viscosity, its units are known as centistokes and one

centistoke is one millimetre squared per second. It is important to remember that as temperature increases, the viscosity of an oil decreases.

The SAE or Society of Automotive Engineers has a grading system that describes the viscosities of oils that are used in all automotive applications from motor scooters, to family cars to 4x4s to buses and trucks and bulldozers. There are two parallel systems, one for engine oils and one for gear oils. The numbers and letters associated with the SAE system are shown below.

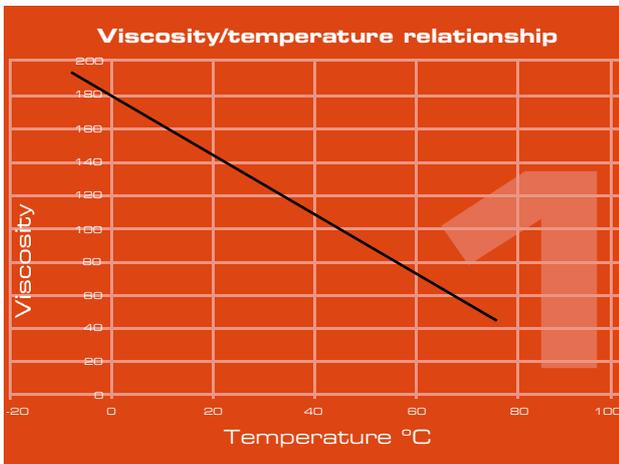
Engine oils	0W	5W	10W	15W	20W	25W	20	30	40	50	60
Gear oils	70W	75W	80W	85W	90	140	250				

The reason for two systems is that gear oils have very different chemical properties from engine oils as they have to perform different functions. You might get away with putting an engine oil in a gearbox but you certainly won't do your engine any good by putting a gear oil in it. If it's a big number (more than 60) it's a gear oil, if it's a small number (less than 70) it's an engine oil. This is simply to avoid confusion. It is important, however, to note that both series cover the same range of viscosities. An SAE 30 engine oil is just as thick as an SAE 85W gear oil.

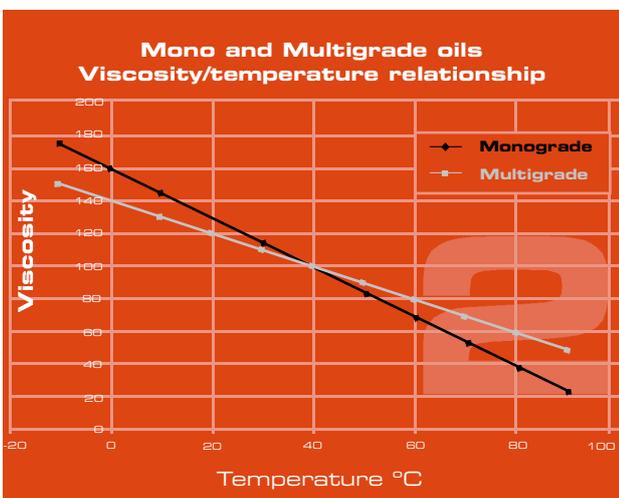
You will note that some of the grades have a 'W' after them. These are the lower or thinner grades that function better at low temperatures as all oils will be thicker when it is cold. These grades can also be blended with other non-W grades to form what are known as multigrade oils. Monograde oils have such designations as SAE 10W or SAE

90 whereas the multigrades have names such as 20W50 or 80W90. Remember, if you increase the temperature of an oil you will decrease its viscosity.

A temperature viscosity graph might look something like this:



On a very cold winter's morning in Bethlehem, the temperature might be as low as -10 degrees but at operating temperatures the engine will have heated the oil to 90 degrees. Ideally what you need is a fairly thin oil that will flow at low temperatures but doesn't thin out too much as the engine reaches operating temperature. Multigrade oils are formulated to perform under exactly these conditions as they thin out less than monograde oils when they are heated. The following graph is an exaggerated illustration of how the two types of oils behave:



The advantage of using a multigrade oil is that its viscosity is more stable over a greater range of temperatures. In effect, a 20W50 will behave like an SAE 20W when it is cold and an SAE 50 when it is hot, providing protection for your engine over a wide range of conditions. The 'W', in fact, stands for Winter.

Well, that has dealt with the physical properties of the oil, but what about the chemicals that are added to the base stock in order for the oil to do its specific job? In other words, if I buy a can of oil, how good is it?

THE CHEMICAL PROPERTIES OF OIL

The most important thing to realize at this point is that if you buy oil from any reputable oil company there is no such thing as a 'bad oil'. You can certainly get cheap oil and you can pay up to R200 a litre if you really want to; you get what you pay for but there are no 'bad oils'.

So, how do you know how much bang you are getting for your buck? Engine oils (and to a lesser extent gear oils) are graded according to performance specifications.

There are any number of international bodies that are equipped and certified to carry out testing to confirm whether a certain product meets internationally accepted performance criteria.

The one that most people are familiar with is the API or American Petroleum Institute although Europe has ACEA, Japan has JAMO and even our own SABS has specifications for lubricants. There is only space here to look at the API which grew out of the US military classification system.

Systems such as the API came into being when engine manufacturers started communicating their needs to the oil companies. When an engine oil is blended, many chemicals (additives) are added to the

oil. These additives impart certain properties to the oils enabling them to function in a desired manner. Below is a list of some typical additives and what their functions are:

ADDITIVE	FUNCTION
Anti-wear	Reduces friction thereby reducing wear
Extreme Pressure agent	Prevents scoring and seizure
Corrosion inhibitor	Prevents rusting, particularly during storage
Detergent	Keeps surfaces free of deposits
Dispersant	Keeps deposits in suspension
Friction modifier	Alters the frictional properties of the oil
Pour point depressant	Permits oil to flow at low temperatures
Seal swell agent	Prevents seals from leaking
Viscosity index improver	Ensures viscosity stability over a wide temperature range
Anti-foamant	Reduces foaming
Anti-oxidant	Retards oxidation of the oil
Metal deactivator	Inhibits the catalytic oxidation of the oil by some metals

The right combination of the right additives in the right amount are blended with a refined crude oil (base stock) in order for an oil to do its job. The API grades these oils on how well they can do that job. Most API specifications are of the format Sx/Cy where x and y are letters of the alphabet; the first half of the designation refers to petrol engines and the second half to diesel engines. The full range is shown below:

Petrol engines	Diesel engines
SA	CA
SB	CB
SC	CC
SD	CD
SE	CE
SF	CF4
SG	CG4
SH	CH4
SJ	CI4
SL	CI4+
SM	

The S designates petrol engines and stands for spark as these are spark ignition engines, the C stands for compression as diesel engines employ compression ignition. Basically, the further you go in the alphabet, the 'better' the oil is. What this actually means is that an SM oil has passed a greater variety and more stringent performance tests than an SG oil.

Most engine oils will generally meet both an S and a C classification, for example SL/CF4. The diesel specification is usually lower as the combustion of diesel puts much higher demands on the lubricant; the combustion by-products of diesel are much more aggressive than for petrol.

In order to grade engine lubricants, engine manufacturers have designed a series of tests to be carried out under scientifically controlled conditions. Most major engine manufacturers are involved and, in order for an oil to achieve an API specification, all tests must be passed to the level stipulated by the manufacturers.

These performance tests do not look at overall performance, but specific characteristics of the oil under test. For example, the Caterpillar IG2 test is used to determine the ability of the oil to protect against ring sticking, wear and accumulation of deposits under high speed turbo-charged conditions. The Peugeot TU3 test is used to measure the ability of the oil to protect against valve train scuffing.

All tests are defined by the ASTM (American Society for Testing and Materials) which works closely with the API and the SAE. The SAE defines the need for a new specification (in conjunction with oil companies and additive manufacturers), the ASTM develops the tests and the API defines the new oil category. This is a very lengthy, complicated and consultative process as all stakeholders need to be involved.

This also explains why a simple oil analysis laboratory cannot determine if an oil meets a particular specification or not. Chemical and physical tests cannot replace actual performance testing and the costs to an oil company trying to get a new product certified runs into millions of dollars. Whether a product meets a specification or not is

actually an act of faith as it is not within the means (in terms of cost or facilities) of the man in the street to have it checked.

The gear oils are graded in a similar way by the API. These oils will have what is known as a GL rating, GL stands for Gear Lubricant. The GL rating measures the level and effectiveness of the EP (Extreme Pressure) additive in the oil. EP additives prevent scoring and scuffing of gears under high load applications.

The scale runs from GL1 to GL6 (although GL6 is technically obsolete), GL1 having the lowest EP level and GL6 the highest. Oils typically found in automotive applications are GL4 and GL5. GL4 oils would normally be used in a manual gearbox application and GL5s in the differential.

As environmental legislation puts heavier and heavier demands on engine manufacturers, the engine manufacturers are putting heavier and heavier demands on the lubricants. Rather than put the muck in the atmosphere, let's put it in the oil. Engine oils work very much harder than they did ten years ago.

One group of oils that hasn't been discussed needs to be touched on just briefly and that is synthetic lubricants.

SYNTHETIC LUBRICANTS

Crude oil is removed from the ground, refined and then additives are blended to produce the finished product. The refining process removes undesirable entities from the crude oil until a finished product is arrived at that will do the job. This does not remove all the nasties, just the ones we really can't live with.

A synthetic oil is a base stock that has been designed, in a laboratory, with all the desired properties and none of the undesirables. This makes synthetic lubricants vastly superior to mineral ones. However, there

is a cost involved. Synthetic oils are very good but they are also very expensive.

Sadly, a landmark legal battle between Mobil and Castrol about five years ago has meant that the definition - synthetic oil - has become so blurred that it really has very little meaning anymore. When purchasing a synthetic oil just be very careful that you know what you are buying.

HOW DOES OIL WORK?

So, we have dealt with the physical and chemical properties of oils and their performance specification but how does the stuff actually work?

Depending on which book, manual or learned journal you read, a lubricant can have as many as two dozen functions. These can be reduced to four very fundamental ones with anything subsequent, more or less being a subdivision of one of these groups.

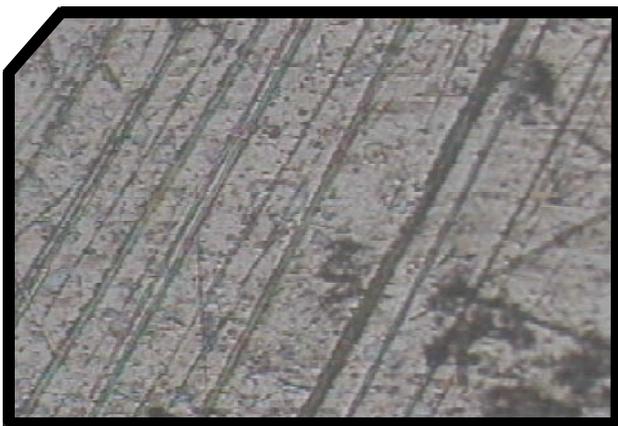
An oil must reduce friction, remove contaminants, cool and act as a structural material. An oil cools by absorbing heat and carrying it to the radiator. It keeps the engine clean by carrying contaminants to the filter for removal. It has viscosity and 'body' so can act as a structural material (think of oil as making a seal between the ring and the bore). But how does oil reduce friction? That is the prime function of a lubricant.

Friction is a ubiquitous part of our daily lives, we spend large amounts of energy just trying to overcome it whether it be walking, driving to work or opening a door. Although friction is often thought of as a negative mechanical characteristic (20% of a car's energy is used to overcome it) it must be remembered that without it you would not be able to walk and the brakes on your car wouldn't work.

Friction is usually seen as a mechanical problem and the force required to overcome it has long interested engineers. When man invented the wheel it enabled him to move

weights around far more easily than dragging them from A to B. What he had in fact done was to replace sliding friction with rolling friction which has a much lower value.

Surfaces that appear smooth and shiny to the naked eye will show peaks and furrows on closer inspection. This does not mean that the component has been poorly machined but components manufactured to high tolerances still have rough surfaces at a microscopic level.



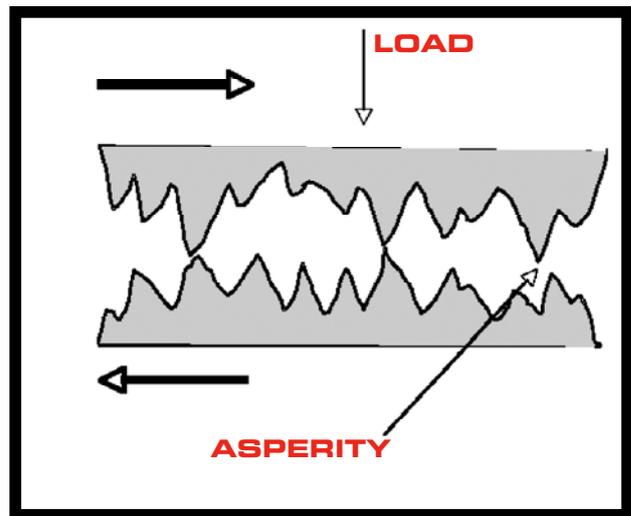
A roller element magnified 200 times.

The rough bits that stick up from the surface are known as asperities. These peaks touch and very high temperatures and pressures are achieved which can cause momentary welding of the surfaces to take place. When the surfaces slide over each other these welds are torn apart.

Whenever friction is overcome, the dislocation of surface material generates heat which can be highly destructive. Additionally, when there is solid friction, wear will take place.

Material is lost due to the cutting action of opposing asperities and the shearing of microscopic welds. In extreme cases the combination of high frictional temperatures, welding and shearing can result in complete seizure.

The harmful effects of friction cannot be overemphasised. The job of a lubrication engineer is to control it; lubrication reduces friction by replacing solid friction with fluid friction.



When one body slides over another, the force of resistance is known as sliding friction. If a ball were to roll over a metal surface, the relative velocity of the points of contact are actually zero and this results in rolling friction. However, there will always be some deformation of the contacting surfaces so some sliding friction is always involved. Tests have shown that rolling friction is not influenced by the presence or absence of a lubricant, however, the deformation spoken about and the presence of sliding means that the oil is a very necessary component of a ball bearing.

The friction that exists between two bodies in relative motion can involve an appreciable energy loss that needs to be minimised. This is achieved by feeding a lubricant between those surfaces in order to replace solid friction with fluid friction. Unfortunately friction can never be eliminated as there will be internal viscous drag (fluid friction) of the oil. In ideal situations the oil will cause the surfaces to separate completely. Where this is not possible, the oil can still keep friction to manageable proportions.

Three parameters need to be considered when looking at the various lubrication regimes. They are: the speed at which the surfaces are moving relative to each other, the load placed on those surfaces and the viscosity of the oil. Ideally, there should be high speed, low load and high viscosity; under these conditions the surfaces would always be separated. Unfortunately we do not live in an ideal world.

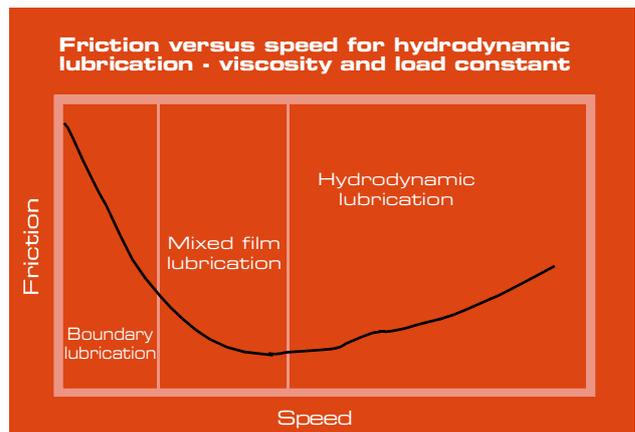
In the case of a plain bearing and journal there will always be a small amount of oil between the mating surfaces. However, at start up, the speed will be zero and the lubricant will not keep the surface completely apart - some of the asperities will touch. This is known as boundary lubrication. In this situation it is the additives in the oil that help to minimise friction. As the speed of the journal increases, pressure differentials cause oil to be sucked between the bearing and the journal. This is known as mixed film lubrication. At this point the surfaces are not quite separated but are supported by a full fluid film.

Finally, the speed becomes fast enough for the surfaces to become totally separated and the solid friction is replaced, totally, by fluid friction. This is known as hydrodynamic lubrication. Unlike solid friction, fluid friction is dependent on speed and will gradually increase. Friction is actually at a minimum during the mixed film regime. The graph alongside illustrates this.

Finally there is another regime that goes under the rather grand name of elastohydrodynamic lubrication. So far we have only considered mating surfaces that have the same geometry, sort of the way that spoons stack together. But what about a roller bearing where the mating surfaces are not of the same shape?

As already mentioned, pure rolling friction should not require lubrication but the contacting surfaces deform elastically when

placed under pressure or load. Oil is drawn into this contact but because this takes place over a vanishingly small area, huge pressures are generated of the order of one and a half million kPa. At these pressures the lubricant takes on the consistency of window putty (reversibly) and is capable of keeping the sliding friction to manageable proportions in this type of situation.



It is not easy to cram so much information into such a small space but it is hoped that this gives a little bit of background on what oils are available and how they work. The important thing to remember is: use the right product, in the right place, at the right time and in the right quantity. Also, keep your fuel, lubricant, air and coolant clean - and most of your maintenance problems will be solved.

John Evans is diagnostic manager for Wearcheck Africa.

Copies of previous Technical Bulletins can be accessed on Wearcheck's web site: www.wearcheck.co.za

If you would prefer to receive future issues of Wearcheck Monitor and Technical Bulletin via e-mail instead of in printed form, please e-mail a request to: support@wearcheck.co.za

THE LEADING OIL ANALYSIS COMPANY IN AFRICA

KWAZULU-NATAL
9 LE MANS PLACE
WESTMEAD, PINETOWN RSA
PO BOX 15108, WESTMEAD 3608
TEL :+27(31) 700 5460
FAX :+27(31) 700 5471
support@wearcheck.co.za
www.wearcheck.co.za



GAUTENG
25 SAN CROY OFFICE PARK
DIE AGORA RD, CROYDON RSA
PO BOX 284, ISANDO 1600
TEL :+27(11) 392 6322
FAX :+27(11) 392 6340
jhbsupport@wearcheck.co.za
www.wearcheck.co.za



Publications are welcome to reproduce articles or extracts from them providing they acknowledge Wearcheck Africa, a member of the Set Point group.