WEAR CHECK AFRICA

TECHNICAL BULLETIN

ISSUE 7

How to read a can of oil (Part 1)

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Oil classifications either describe viscosity or performance

Viscosity decreases as temperature increases

When purchasing a can, drum or tankerful of oil, it is important to realise that a number of international classification systems are used to describe the product and its uses. The classifications, which include ISO, SAE, API, CCMC, SABS, JAMA and ISLS, are each followed by a series of numbers and letters detailing either the viscosity of the oil or its performance properties. This bulletin will examine viscosity classification while the performance characteristics of oil will be covered in a later issue.

Viscosity

The most important property of an oil is its viscosity. This is defined as the oil's resistance to flow at a specified temperature. It is a measure of the oil's 'thickness'; 'thick' oil has a high viscosity while 'thin' oil has a low viscosity. A fluid's resistance to flow is known as kinematic viscosity and this is the measurement that is of greatest concern to industries which use lubricants. Kinematic viscosity is measured in centistokes (cSt) and one centistoke equals one millimetre squared per second. The symbol for viscosity is denoted by the Greek letter 'eta'. Therefore:

Kinematic Viscosity η_k = 1 Centistoke (cSt) = 1 mm^2/S

It is important to note that as temperature increases, viscosity decreases, so one must always state the temperature at which viscosity is measured, otherwise the reading will be meaningless.

Two industry standards are used when measuring kinematic viscosity, namely 40°C and 100°C. The type of oil under consideration and its properties determine which temperature is employed, although 40°C is used most commonly.

Kinematic viscosity is not the only viscosity measurement that can be made; there is also dynamic

Generally, hydraulic fluids are lower viscosity oils and gear fluids are higher viscosity oils

viscosity (sometimes called absolute viscosity) which is a measurement of a fluid's resistance to shear at a specified temperature. Dynamic viscosity is measured in centipoise and one centipoise equals one millipascal second.

Dynamic Viscosity η_D = 1 Centipoise (cP) = 1 mPa.S

The two viscosity measurements are related to one another by the density of the fluid:

$$\eta_D / \rho = \eta_K$$

Dynamic viscosity is of little concern when describing an oil's viscosity grade. Oil grades are usually described in kinematic viscosity (normally at 40°C). Although centistoke units will be used throughout this bulletin, different units are used in other parts of the world e.g. Engler Degrees (Europe), Redwood Seconds (UK), and Saybolt Universal Seconds (USA). The different systems are convertible but only for measurements made at the same temperature.

The ISO VG system

The International Standards Organisation, Viscosity Grade (ISO VG) is a grading system that is generally used to describe industrial oils i.e. oils used in stationary plant (pumps, turbines, gearboxes, compressors, etc.). The numbers associated with the ISO VG are as follows:

ISO VISCOSITY GRADE (ISO VG)		
2	22	220
3	32	320
5	46	460
7	68	680
10	100	1000
15	150	1500

These numbers refer to the kinematic viscosity of the oil in centistokes at 40°C. This means that an ISO 320 oil has a kinematic viscosity of 320 cSt at 40°C. The beauty of this system is that the name of the oil states its viscosity. For example, Caltex Meropa 460 is an industrial gear circulating oil with a viscosity of 460 cSt.

Generally, the lower viscosity oils are hydraulic fluids and the higher viscosity oils are gear fluids. There is no exact cut-off point where gear oils become hydraulic oils, but ISO 150 is a good approximation. Some ISO 68 oils can be used in high speed, low load gearboxes and some ISO 320 oils can be used in compressors with very high discharge temperatures.

When measuring the viscosity of an ISO oil, do not expect an ISO 100 to have a viscosity of exactly 100 centistokes. According to the ISO, 10% leeway is allowed either way, so any industrial oil with a viscosity between 90 and 110 cSt would be considered an ISO 100, and even the same brand and grade might vary slightly from batch to batch.

There are some intermediate grades in common usage which are not ISO approved. These oils have viscosities of 37, 56 and 77 cSt but are not officially ISO viscosity grades.

Although this numbering system may appear arbitrary, each subsequent grade is approximately a 50% increase on the previous grade. This gives a wide enough range of products to meet industry's needs without flooding

SAE is a viscosity grading system for gear oils and engine oils used in the automotive industry

the market with a different grade for each centistoke increase in viscosity.

The SAE system

The Society of Automotive Engineers (SAE) is a viscosity grading system for oils used in the automotive industry. To avoid confusion it is divided into two subclasses, one for gear oils and one for engine oils. A high number (greater than 60) means that the oil is formulated for a gear type component while a low number corresponds to oil which is used in the engine. The numbers associated with the SAE system are shown immediately below:

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

Unlike the ISO system, the SAE system does not give the viscosity of the oil in centistokes at 40°C, although the higher the number, the higher the viscosity. The equivalents of the ISO and SAE viscosity grades are shown on Page 5.

The SAE grades are more carefully quantified than the ISO oils; both dynamic and kinematic viscosities are used, as well as both 40°C and 100°C temperatures.

Grades with the letter 'W' are used at lower ambient temperatures and are classified according to a maximum low temperature dynamic viscosity and a maximum borderline pumping temperature as well as a minimum kinematic viscosity at 100°C. The dynamic viscosity measurement correlates with engine speeds during low temperature cranking while the borderline pumping temperature measures the oil's ability to flow to the engine oil pump and provide adequate oil pressure during start up. Grades without the 'W' are used in higher operating conditions and are based solely on their kinematic viscosities at 100°C.

From the chart on Page 5 it can be seen that the SAE gear and engine numbers cover the same range of viscosities; for example, an SAE 30 engine oil has approximately the same viscosity as a SAE 85W gear oil. This is because the formulation of engine oils is very different to that of gear oils in the automotive industry. An engine oil is far more stressed than a gear oil because it must cope with combustion by-products and blow-by gases which severely degrade the oil. As a result engine oils contain a much wider variety of additives than gear oils. Although not ideal, an engine oil will function in a gearbox while a gear oil will destroy an engine.

Monogrades and multigrades

Engine (and gear type) oils come in a variety of grades ranging from 0W to 50 as the table on Page 4 shows. These are known as monograde oils, but multigrade oils are also available with SAE gradings like 15W30, 15W40, 20W50 etc.

All multigrade oils have the viscosity properties of a low temperature 'W' oil and a high

Engine oil is more stressed than gear oil because of combustion by-products and blow-by gases

GEAR OILS

SAE Viscosity Grade	Max Temperature for Viscosity of 150 000 cP Max	(cSt) Viscosity at 100°C Min	Max
75W	-40	4,1	
80W	-26	7,0	
85W	-12	11,0	
90		13,5	24,0
140		24,0	41,0
250		41,0	

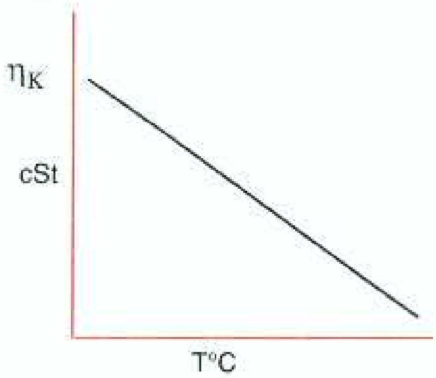
ENGINE OILS

SAE Viscosity Grade	Viscosity (cP) at Temperature (°C) Max	Borderline Pumping Temperature (°C) Max	(cSt) Viscosity at 100°C Min	Max
0W	3250 @ -30	-35	3,8	
5W	3500 @ -25	-30	3,8	
10W	3500 @ -20	-25	4,1	
15W	3500 @ -15	-20	5,6	
20W	4500 @ -10	-15	5,6	
25W	6000 @ -5	-10	9,3	
20			5,6	< 9,3
30			9,3	< 12,5
40			12,5	< 16,3
50			16,3	< 21,9

temperature oil without the 'W' suffix.

An SAE 40 and an SAE 20W50 both have roughly the same viscosity (kinematic) at 40°C; they both approximate an ISO 150 oil. What then is the difference between a monograde and a multigrade oil in viscosity terms?

Remember that if temperature is increased, viscosity will decrease. A viscosity versus temperature graph might look something like this.



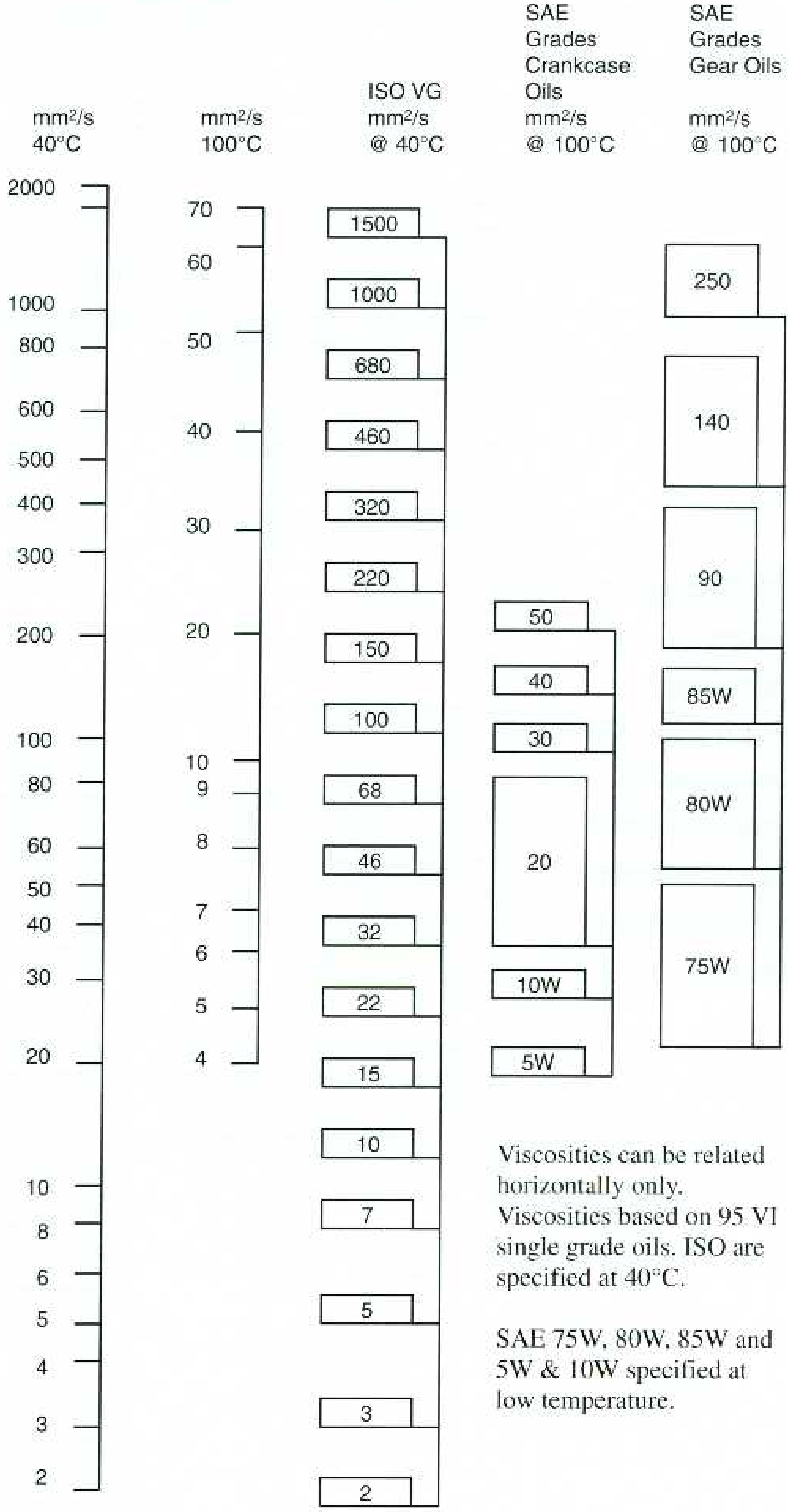
The viscosity is high at low temperatures and low at high temperatures. However, not all oils behave in the same manner. Some oils 'thin' out less than others when the temperature is increased. This is the difference between a multigrade and a monograde oil.

On a very cold winter morning the temperature could be -5°C but when the engine reaches full operating temperature it might be 100°C. Ideally, what is required is a fairly low viscosity oil which will flow readily at low temperatures without thinning out too much when operating temperature is reached. Multigrade oils are formulated to do this.

The graph on Page 6 is an exaggerated illustration of the difference between monograde and multigrade oils.

APPROXIMATE VISCOSITY EQUIVALENTS

SAE gear and engine numbers cover the same range of viscosities

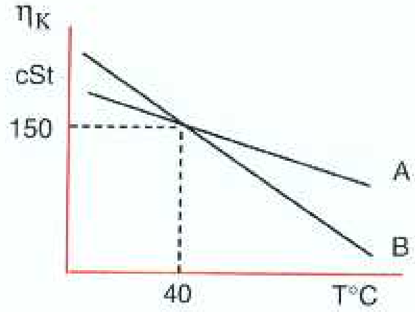


Viscosities can be related horizontally only. Viscosities based on 95 VI single grade oils. ISO are specified at 40°C.

SAE 75W, 80W, 85W and 5W & 10W specified at low temperature.

Multigrade oil has greater viscosity stability over a wider range of temperatures than monograde oil

Oil B is typical of a monograde (SAE 40) oil which thins out as temperature is increased. Oil A thins out less and is typical of a multigrade (20W50) oil.



SAE Grade	Viscosity Index
40	95
20W50	135

This introduces the concept of the Viscosity Index (VI) which is a measure of an oil's 'multigraded-ness'. The higher the VI, the more multigraded the oil. In the above example, SAE 40 (monograde) has a low VI while SAE 20W50 has a high VI.

The advantage of using a multigrade oil is that it has greater viscosity stability over a wider range of temperatures. The oil behaves like an SAE 20W when it is cold and an SAE 50 when it is hot. The 'W' in all the SAE grades actually denotes 'winter'.

Monogrades versus multigrades

If a multigrade oil's viscosity stability with varying temperature is so useful, what is the point of having monograde oils? The reason is that a number of the additives used to enhance the VI of an oil are unstable in a working environment. The biggest problem is that they tend to shear, that is physically degrade. This is well illustrated in Shell's 'ice skating' television commercial. If a multigrade oil is subject to high shearing stress e.g. a powershift transmission, the additive which imparts the high VI will start to break up, resulting in a sharp drop in viscosity. This could be detrimental to the component, causing the oil to lose its load-bearing characteristic and, under these circumstances, a monograde oil might be the safer choice.

The question "Is one oil better than another?" will be discussed in a future Wearcheck Technical Bulletin, looking specifically at ISLS, API and other classification systems which describe an oil's performance and usage characteristics.

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