Reading Oil Specs - Part 1

Viscosities, grading systems, monogrades and multigrades - what it all means.

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Oil classifications either describe viscosity or performance. 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.

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 people using 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 nK = 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 temperature standards are used when measuring kinematic viscosity, namely 40 degrees C and 100 degrees C. The type of oil under consideration and its properties determine which temperature is employed, although 40 degrees C is used most commonly. Kinematic viscosity is not the only viscosity measurement that can be made; there is also dynamic 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 nD = 1 centipoise (cP) = 1 mPa.S

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

nD / p = nK

Dynamic viscosity is of little concern when describing an oil's viscosity grade. Oil grades are usually described in kinematic viscosity (normally at 40 degrees C). Although centistoke units will be used throughout this article, 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 ie 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 degrees C. This means that an ISO 320 oil has a kinematic viscosity of 320 cSt at 40 degrees 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 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 below:

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

Unlike the ISO system, the SAE system does not give the viscosity of the oil in centistokes at 40 degrees C, although the higher the number, the higher the viscosity. 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 degrees 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 degrees C.

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.

Gear Oils

SAE Viscosity	**Max Temperature for Viscosity of 150,000 cP**	**(cSt) Viscosity at 100 degrees C**
Grade	Max	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	**Viscosity (cP) at Temp (degrees C)**	**Borderline Pumping Temp (degrees C)**	**(cSt) Viscosity at 100 degrees C**
Grade	Max	Max	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 -