IB006. VISCOSITY CLASSIFICATION

" For any oil lubrication system, viscosity will always be the most important parameter to ensure that the viscosity of the oil meets with the OEM recommendations and requirements. "

Viscosity

Viscosity is the measure of internal friction in a fluid.

Viscosity can be defined as measurement of the lubricant internal resistance to flow at a specified temperature. It can be measure in two ways, namely Dynamic (Absolute) Viscosity and Kinematic Viscosity.

Kinematic Viscosity is defined as a measure of the resistance of a fluid to flow under gravitational force. It is reported in Centistoke unit (cSt). (1cSt = 0.01 St = 1mm²/s)

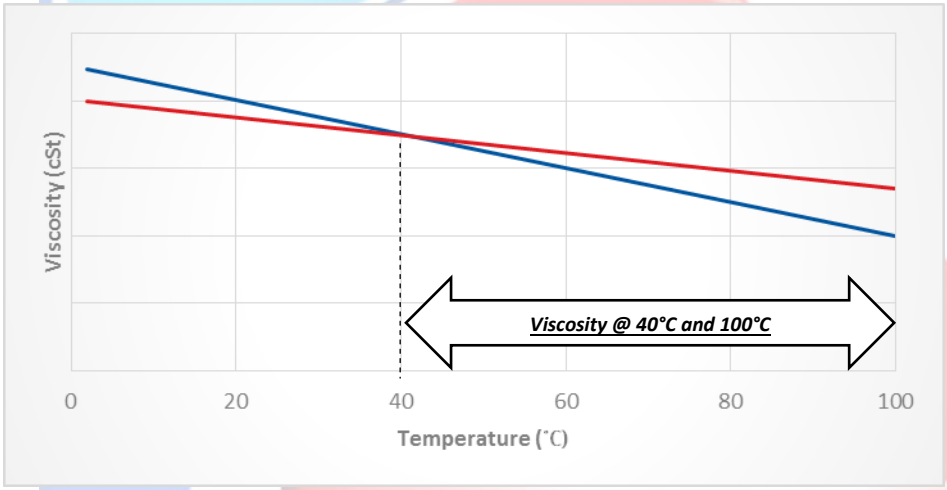
Dynamic (Absolute) Viscosity is defined as a fluid's resistance to flow to deform when subjected to a force. It is reported in Centipoise (cP). (1cP = mPa.s)

The Kinematic Viscosity is commonly used by most laboratories, whereas Dynamic Viscosity is mostly used on-site equipment. Nevertheless, both measurements are interchangeable with the below formula:

$$Dynamic\ Viscosity\ (cP) = Kinematic\ Viscosity\ (cSt) x\ Fluid\ Density\ (kg/m^3)$$

Viscosity Index

Viscosity of a lubricant is highly dependable on the temperature, thus to assess a lubricant property, Viscosity Index (VI) is introduce as an arbitrary scalar value that indicate the changes in an oil's viscosity with changes in its temperature. A high Viscosity Index indicates less viscosity change when temperature increases which indicates better resistance to thinning and possible better film strength retention under heat conditions.



Oil Viscosity Grade

Lubricants are classified according to their viscosity by various technical societies such as the Society of Automotive Engineers (SAE), International Organization for Standardization (ISO), American Gear Manufacturer Association (AGMA), thus it can be confusing to determine what is the viscosity of fluid in a viscosity system of interest if the viscosity is quoted in units of another viscosity systems

Viscosity Classification - International Standards Organisation (ISO)

The ISO viscosity classification uses mm^2/s (cSt) units and relates to viscosity at 40°C, it consists of 18 ISO viscosity grades that are defined by numbers. This series of 18 viscosity brackets have kinematic viscosity at 40°C ranging from minimum of 1.98 mm^2/s to a maximum of 1650 mm^2/s. For example, ISO VG 68 refers to a viscosity grade of 68 with minimum kinematic viscosity at 61.2, maximum kinematic viscosity at 74.8, and mid-point viscosity at 68.0.

ISO Viscosity Grade (ISO VG)	**Kinematic viscosity at 40°C (mm^2/s = cSt)**		
	Mid-point	Minimum	Maximum
2	2.20	1.98	2.42
3	3.20	2.88	3.52
5	4.60	4.14	5.06
7	6.80	6.12	7.48
10	10.0	9.0	11.0
15	15.0	13.5	16.5
22	22.0	19.8	24.2
32	32.0	28.8	35.2
46	46.0	41.1	50.6
68	68.0	61.2	74.8
100	100	90.0	110
150	150	135	165
220	220	198	242
320	320	288	352
460	460	414	506
680	680	612	748
1000	1000	900	1100
1500	1500	1350	1650

Viscosity Classification - American Gear Manufacturers Association (AGMA)

The American Gear Manufacturers Association (AGMA) has issued specifications and recommendations for gear lubricants used in various types of gear application. The AGMA numbers let the user know the ISO viscosity grade and some basic information about the gear lubricant's chemistry. If the product is a mineral oil that contains only rust and oxidation (R&O) additives, it will be recognized with only the AGMA number. If it is a mineral oil with extreme pressure additives, it is recognized with the AGMA number followed by the "EP" term.

AGMA Lubricant Number	Viscosity Limits of former AGMA Classifications SUS at 100°F	Corresponding ISO Viscosity Grade
1	193 - 235	46
2, 2 EP	284 – 347	68
3, 3 EP	417 – 510	100
4, 4 EP	626 – 765	150
5, 5 EP	918 – 1122	220
6, 6EP	1335 – 1632	320
7 Comp, 7 EP	1919 – 2346	460
8 Comp, 8 EP	2837 – 3467	680
8A Comp	4171 – 5098	1000

Viscosity Classification (Engine Oil) - Society of Automotive Engineers (SAE)

The Society of Automotive Engineers (SAE) has created the SAE J300 as a viscosity classification for engine oils. In the SAE J300 classification, the grades denoted with the letter “W” are intended for use in applications operating in low-temperature conditions, whereas the grades without a “W” are recognized as mono-grade lubricants that are intended for use in applications operating in higher temperatures conditions.

SAE J300 Viscosity Grades for Engine Oil (January 2009)

SAE Viscosity Grade	Low-Temperature (°C)		Low-Shear-Rate Kinematic Viscosity, (MM^2/S) at 100°C		High-Shear-Rate Viscosity (MPA●S) AT 150°C MIN.
	CRANKING VISCOSITY (1 mm^2/s) MAX.	PUMPING VISCOSITY (1 mm^2/s) MAX. WITH NO YIELD STRESS	Minimum	Maximum	
0W	6,200 at -35	60,000 at -40	3.8	-	-
5W	6,600 at -30	60,000 at -35	3.8	-	-
10W	7,000 at -25	60,000 at -30	4.1	-	-
15W	7,000 at -20	60,000 at -25	5.6	-	-
20W	9,500 at -15	60,000 at -20	5.6	-	-
25W	13,000 at -10	60,000 at -15	9.3	-	-
20	-	-	5.6	<9.3	2.6
30	-	-	9.3	<12.5	2.9
40	-	-	12.5	<16.3	3.5 (0W-40, 5W-40, 10w-40 GRADES)
40	-	-	12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40 grades
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

Viscosity Classification (Gear Oil) - Society of Automotive Engineers (SAE)

The classification is based on the lubricant viscosity measured at low and/or high temperatures. The high temperatures values are determined according to method ASTM D445. The low temperature values are determined according to method ASTM D2983 'Method of Test for Apparent Viscosity at Low Temperature using the Brookfield Viscometer' and are measured in mPa.s (c.P).

Multi-grade oil satisfies the viscosity requirements of one of the W grades at low temperatures and one of the non-W grades at high temperature.

It should be noted that there is no relationship between the SAE engine oil and gear oil classifications. A gear lubricant and an engine oil having the same viscosity will have different SAE grade designation as defined in the two classifications.

Automotive Gear Lubricant Viscosity Grades Classification SAE J306 (January 1, 2005)

SAE Viscosity Grade	Maximum Temperature For Viscosity of 150,000 CP (°C)	Kinematic Viscosity at 100°C (cst)	
	Max.	Min.	Max.
70W	-55	4.1	-
75W	-40	4.1	-
80W	-26	7.0	-
85W	-12	11.0	-
80	-	7.0	<11.0
85	-	11.0	<13.5
90	-	13.5	<18.5
110	-	18.5	<24.0
140	-	24.0	<32.5
190	-	32.5	<41.0
250	-	41.0	-

Grease Consistency Classifications

For some lubricant applications, it is impossible to encompass a fluid lubricant therefore greases are being utilised. Grease is a semi-solid lubricant composed of base oil, performance additives and a thickener. The thickener in grease is added to hold and help remain in contact on the applications without leaking out under the force of gravity, centrifugal action or being squeezed out under pressure. Because greases are not a fluid, their resistance to flow is generally called consistency instead of viscosity. The measure of the consistency of a lubricating grease is commonly expressed by its NLGI consistency number, defined by the National Lubricating Grease Institute.

NLGI Consistency Number	ASTM Worked Penetration at 25°C (0.1MM)
000	445 – 475
00	400 – 430
0	355 – 385
1	310 – 340
2	265 – 295
3	220 – 250
4	175 – 205
5	130 – 160
6	85 – 115

API Service Classification (Engine Crankcase Oils)

The American Petroleum Institute (API) Engine Service Classification was developed as a result of a co-operative effort in the USA between the API, the American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE). The tripartite was developed to form a means of communication between the engine manufacturers and lubricants suppliers.

The system defines classes of service for both petrol and diesel engine applications as well as stipulating the accepted engine laboratory tests.

For compression ignition engines (diesel engines), the letter 'C' (Commercial Classifications) has been designated. The following is a brief summary of the API classifications.

API Engine Service Categories (Diesel Engines)

Category	Status	Service
CJ-4	Current	Introduced in 2006. For high-speed, four-stroke engines designed to meet 2007 model year on-highway exhaust emission standards. CJ-4 oils are compounded for use in all applications with diesel fuels ranging in sulfur content up to 500ppm (0.05% by weight). However, use of these oils with greater than 15ppm (0.0015% by weight) sulfur fuel may impact exhaust after-treatment system durability and/or oil drain interval. CJ-4 oils are effective at sustaining emission control system durability where particulate filters and other advanced after-treatment systems are used. Optimum protection is provided for control of catalyst poisoning, particulate filter blocking, engine wear, piston deposits, low and high-temperature stability, soot handling properties, oxidative thickening, foaming, and viscosity loss due to shear. API CJ-4 oils exceed the performance criteria of API CI-4 with CI-4 PLUS, CI-4, CH-4, CG-4 and CF-4 and cn effectively lubricate engines calling for those API Service Categories. When using CJ-4 oil with higher than 15ppm sulfur fuel, consult the engine manufacturer for service interval.
CI-4	Current	Introduced in 2002. For high-speed, four-stoke 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 sulphur 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 sulphur context 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 sulphur. CG-4 oils are required for engines meeting 1994 emission standards. Can be used in place of CD, CE and CF-4 oils.

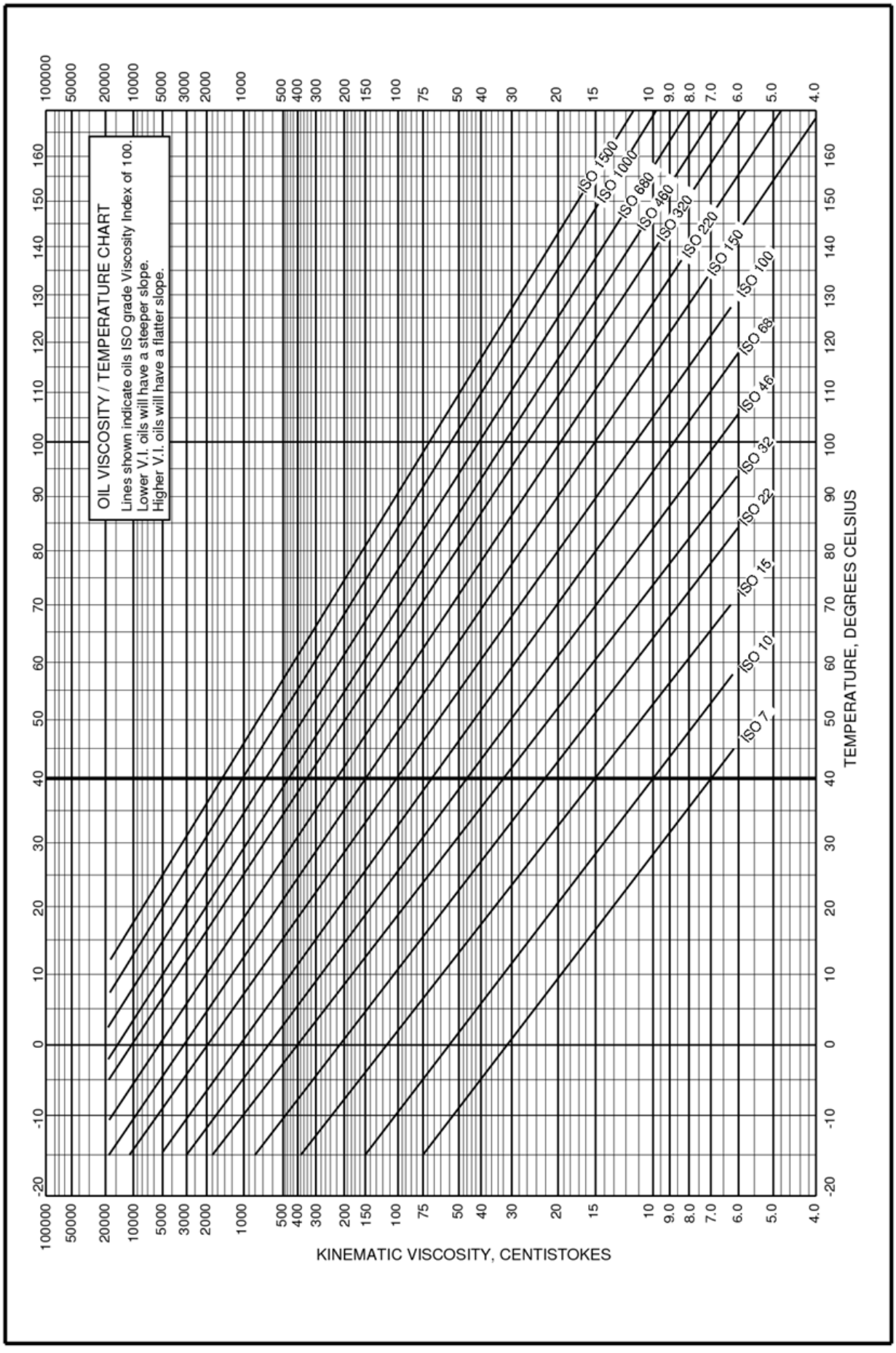
Category	Status	Service
CF-4	Obsolete	Introduced in 1990. For high-speed, four-stroke, naturally aspirated and turbocharged engines. Can be used in place of CD and CE oils.
CF-2	Current	Introduced in 1994. For severe duty, two-stroke-cycle engines. Can be used in place of CD-II oils.
CF	Current	Introduced in 1994. For off-road, indirect-injected and other diesel engines including those using fuel with over 0.5% weight sulphur. 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.

For automotive gasoline engines, the letter 'S' has been designated. The following is a brief summary of the API classifications.

API Engine Service Categories (Gasoline Engines)

Category	Status	Service
SN	Current	Introduced in October 2010, designed to provide improved high temperature deposit protection for pistons, more stringent sludge control, and seal compatibility. API SN with Resource Conserving matches ILSAC GF-5 by combining API SN performance with improved fuel economy, turbocharger protection, emission control system compatibility, and protection of engines operating on ethanol-containing fuels up to E85.
SM	Current	For 2010 and older automotive engines.
SL	Current	For 2004 and older automotive engines.
SJ	Current	For 2001 and older automotive engines.
SH	Obsolete	For 1996 and older automotive engines.
SG	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1993. May not provide adequate protection against build-up of engine sludge, oxidation, or wear.
SF	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1988. May not provide adequate protection against build-up of engine sludge.
SE	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1979.
SD	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1971. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SC	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1967. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SB	Obsolete	Not suitable for use in most gasoline-powered automotive engines built after 1951. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SA	Obsolete	Contains no additives. Not suitable for use in most gasoline-powered automotive engines built after 1930.Use in modern engines may cause unsatisfactory performance or equipment harm.

Viscosity-Temperature Chart



The chart below provides a comparative illustration of all the grades between the different technical society's standards.