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Viscosity Units

The S.I. (Systeme Internationale) unit for Kinematic Viscosity is “meter squared per second” and the “Metric” unit is “centimeter squared per second” and is called the “Stoke”. For testing lubricating oils at 40°C and 100°C, the common unit used is the “Centistokes” (Cstk), which is one hundredth of a stoke.

Worldwide, the centistokes has replaced the once familiar Saybolt Universal Second unit (S.U.S.). The latest S.A.E. specifications for engine oils and gear oils use the centistokes for the specifications for viscosity at 100°C. Canadian and American manufacturers and marketers of lubricants give typical viscosity data in centistokes and, like Metro Tech Systems Ltd., the control test is ASTM D-445, Kinematic Method and the test result is reported in Centistokes.

S.A.E. numbers denote viscosity grades, not test results; the use of an S.A.E. number, as a viscosity unit is a misuse of the system. For example, an oil with a viscosity from 9.3 up/to 12.5 centistokes at 100°C meets the specification for S.A.E.-30 oil.

S.A.E. Engine Oil Viscosity Classification

The Society of Automotive Engineers (S.A.E.) classifies engine oils by ten S.A.E. Viscosity Numbers, commonly called VISCOSITY GRADES or S.A.E. grades. The limits for these grades are summarized in Table 1.

The “W” grades are controlled by a number of measurements related to low-temperature fluidity plus a minimum kinematic viscosity at 100°C. The high-shear Cold Cranking Simulator (CCS) (ASTM D2602 Mod.) measures the ease of cold cranking an engine for cold starts. The low Temperature pumpability test (mini rotary viscometer, or MRV) measures the viscosity at low temperature and under low shear conditions. The 60,000 cP (centipoises) limit is the limiting pumping viscosity, since above this viscosity the oil will not flow continuously to the oil pump inlet during the initial stages. The four non-“W” grades are defined by kinematic viscosity (ASTM D445) at 100°C, which measures the oil’s performance relative to wear and oil consumption.

Table 1

J300 SEP 80-S.A.E. Viscosity Grades for Engine Oils

S.A.E. Viscosity Grade	Max Cranking Viscosity (cP) at Temp. ¹ (°C)	Max Pumping Viscosity (cP) at Temp. (°C) with no Yield Stress ²	Viscosity ³ (cSt.) @ 100°C		High-Shear Viscosity (cP) @ 150°C and 10 ⁶ s ⁻¹ Min. ⁴
			Min.	Max.	
0W	3250 @ -30	60 000 @ -40	3.8	---	---
5W	3500 @ -25	60 000 @ -35	3.8	---	---
10W	3500 @ -20	60 000 @ -30	4.1	---	---
15W	3500 @ -15	60 000 @ -25	5.6	---	---
20W	4500 @ -10	60 000 @ -20	5.6	---	---
25W	6000 @ -5	60 000 @ -15	9.3	---	---
20	---	---	5.6	< 9.3	2.6
30	---	---	9.3	<12.5	2.9
40 ⁵	---	---	12.5	<16.3	2.9
40 ⁶	---	---	12.5	<16.3	3.7
50	---	---	16.3	<21.9	3.7
60	---	---	21.9	<26.1	3.7

NOTE: 1cP = 1mPa.s 1cSt=1mm²/S

¹ ASTM D5293 – Cold Cranking Simulator

² ASTM D4684 - Mini-Rotary Viscometer

³ ASTM D445 – Kinematic viscosity

⁴ High Temperature High Shear ASTM D4683, CEC L-36-A-90 ASTM D4741

⁵ For light duty grades 0W-40, 5W-40 and 10W-40

⁶ For heavy duty grades 15W-40, 20W-40, 25W-40, 40

S.A.E. Gear Oil Viscosity Classification

S.A.E. VISCOSITY CLASSIFICATION system classifies gear oils by viscosity grades. S.A.E. grades 90, 140, and 250 are measured by Kinematic viscosity at 100°C. The W grades 70W, 75W, 80W and 85W are measured by Brookfield viscosity over a range of specific low temperatures. The 100°C viscosity relates to wear, noise and leakage while the low-temperature Brookfield viscosity relates to low-temperature fluidity.

The S.A.E. number designations for gear oil grades were purposely chosen to be completely different from S.A.E. engine oil grade numbers. The intention was to minimize chances of using the wrong type of lubricant, particularly since they differ so much in composition and performance qualities. However, the S.A.E. 70W, 75W, 80W, 85W, and 90W grade gear oils overlap the viscosity range of engine oils. For example, an S.A.E. 75W gear oil of 5.5 cSt at 100°C is typical of an S.A.E. 10W engine oil; an S.A.E. 80W gear oil of 8.0 cSt at 100°C is typical of an S.A.E. 20 engine oil; an S.A.E. 85W gear oil of 12 cSt at 100°C is typical of an S.A.E. 30 engine oil; an S.A.E. 90 gear oil of 15 – 20 cSt at 100°C is equivalent in viscosity to an S.A.E. 40 or 50 engine oil.

Table 2

S.A.E. J306C Lubricant Viscosity Classification

S.A.E. Visc. Number	Max. Temperature For Viscosity of 150,000 cP C	<u>Viscosity – cSt at 100°C</u>	
		Min.	Max.
70W	-55	4.1	
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	

Classification of Industrial Lubricating Oils

International Standard (ISO 3448-1975 (E)), entitled “Industrial Liquid Lubricants – ISO Viscosity Classification”, established a series of lubricant viscosity grades (VG) based on kinematic viscosity at 40°C. Related proposals, which have also gained acceptance, are:

1. use of 40 °C and 100 °C as the principal viscosity measuring temperatures for essentially all types of lubricants and a Viscosity Index System based on these temperatures
2. use of centistokes as the official viscosity unit for this system
3. general use of whole degrees Celsius (Centigrade) for specifications, classifications and various petroleum tests

The centistokes was adopted instead of the official unit of the Systeme International: millimeters squared per second (mm²/S), in recognition of the convenience and long-established use of the centistokes.

The new ISO system has been widely adopted by the petroleum industry as well as by many other industries throughout the world. ASTM (the American Society of Testing and Materials) is committed to full implementation of the ISO system and has revised its method D2422, Viscosity System for Industrial Fluid Lubricants, to conform to ISO 3448. In addition, ASTM has developed the necessary charts and procedures required to implement the new 40° C/100°C kinematic viscosity and Viscosity Index Systems. ASTM method D2770 (IP226), “Calculating Viscosity Index from Kinematic Viscosity”, has been revised for 40°C/100°C “Viscosity Index Tables Calculated from Kinematic Viscosity”, DS 39a has been revised to the 40° C/100°C system.

Table 3 shows all the ISO VG Classifications with their limits.

Table 3

INDUSTRIAL LIQUID LUBRICANTS
ISO VISCOSITY CLASSIFICATION (ISO 3448-1975)

ISO Viscosity Grade	Mid-Point Kinematic Viscosity cSt at 40°C	<u>Kinematic Viscosity Limits</u> cSt at 40°C	
		Min.	Max.
ISO VG2	2.2	1.98	2.42
ISO VG3	3.2	2.88	3.52
ISO VG5	4.6	4.14	5.06
ISO VG7	6.8	6.12	7.48
ISO VG10	10	9.00	11.0
ISO VG15	15	13.5	16.5
ISO VG22	22	19.8	24.2
ISO VG32	32	28.8	35.2
ISO VG46	46	41.4	50.6
ISO VG68	68	61.2	74.8
ISO VG100	100	90.0	110
ISO VG150	150	135	165
ISO VG220	220	198	242
ISO VG460	460	414	506
ISO VG680	680	612	748
ISO VG1000	1000	900	1100
ISO VG1500	1500	1350	1650