VISCOSITY CLASSIFICATIONS

INDUSTRIAL LUBRICANT CASSIFICATIONS

ISO (International Standards Organisation) viscosity classification

The ISO viscosity classification uses mm^2/s (cSt) units and relates to viscosity at 40°C. It consists of a series of 18 viscosity brackets between 1.98 mm^2/s and 1650 mm^2/s, each of which is defined by a number. The numbers indicate to the nearest whole number, the mid points of their corresponding brackets. For example, ISO viscosity grade 32 relates to the viscosity bracket 28.8 to 35.2 mm^2/s, the mid point of which is 32.0 mm^2/s. This is illustrated in the table below, which shows the ISO viscosity grade numbers, the mid-points of each bracket, and the viscosity limits. This system is now used to classify all industrial lubricating oils where viscosity is an important criterion in the selection of the oil. Cutting oil and some other specialized products are more important in relation to grade selection.

ISO VISCOSITY GRADE (ISO VG)	KINEMATIC VISCOSITY AT 40°C (mm^2/s)		
	Minimum	Maximum	Mid-point
2	1.98	2.42	2.20
3	2.88	3.52	3.20
5	4.14	5.06	4.60
7	6.12	7.48	6.80
10	9.0	11.0	10.0
15	13.5	16.5	15.0
22	19.8	24.2	22.0
32	28.8	35.2	32.0
46	41.4	50.6	46.0
68	61.2	74.8	68.0
100	90.0	110	100
150	135	165	150
220	198	242	220
320	288	352	320
460	414	506	460
680	612	748	680
1000	900	1100	1000
1500	1350	1650	1500

GREASE CLASSIFICATIONS

NLGI GREASE CONSISTENCY CLASSIFICATION

The commonly used grease consistency classification is that established in the USA many years ago by the National Lubricating Grease Institute (NLG). This classifies greases solely in terms of their hardness or softness; no other property or performance level is taken into consideration.

The classification consists of a series of consistency range, each of which is defined by a number (or numbers) 000 to 6. The consistency, defined by the distance in tenths of a millimetre, that a

standard cone penetrates a sample of the grease number under standard conditions at 25°C. This system is used to classify industrial greases.

NLGI Grease Classification (National Lubricating Grease Institute)

NLGI CONSISTENCY (Grade No.)	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

AGMA Specifications for Gear Lubricants

The American Gear Manufacturers Association (AGMA) have issued specifications and recommendations for gear lubricants used in various types of gear application. AGMA Standard 250.04 details specifications for rust and oxidation inhibited (R and O) and extreme-pressure (EP) lubricants used in enclosed gear drives.

The viscosity brackets correspond to those given in ASTM D 2422 'Standard Recommended Practice for Viscosity System for Industrial Fluid Lubricants'.

AGMA Viscosity Grades for Enclosed Gearing

AGMA Lubricant No.	Viscosity Limits of former AGMA Classifications SUS at 100ºF	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, 6 EP	1335 – 1632	320
7 Comp, 7EP	1919 –2346	460
8 Comp, 8EP	2837 – 3467	680
8A Comp	4171 – 5098	1000

Oils marked 'comp' are compounded with 3 to 10% fatty material.

The AGMA Standard 251.02 details specifications for three types of open gear lubricants – rust and oxidation inhibited (R and O), extreme-pressure (EP) and residual type gear oils. In this case the viscosity brackets for the higher viscosity grades are measured at 100 C.

LUBRICANT VISCOSITY CLASSIFICATIONS

ENGINE OIL LUBRICANT CLASSIFICATIONS

SAE J300 September 1980 (Engine Oils)

The most widely used system for engine oil viscosity classification is that established by the Society of Automotive Engineers (SAE) in the USA.
In this system two series of viscosity grades are defined – those containing the letter W and those without the letter W.

Grades with the letter W are intended for use at lower temperatures and are based on a maximum low temperature viscosity and a maximum borderline pumping temperature, as well as a minimum viscosity at 100C. The low temperature viscosity is measured by means of a multi-temperature version of ASTM D2602 'Method of Test for apparent Viscosity of Motor Oils at Low temperature using the Cold Cranking Simulator'. Viscosities measured by this method have been found to correlate with engine speeds developed during low temperature cranking. Borderline pumping temperature is measured according to ASTM D3829 'Standard Method for Predicting the Borderline Pumping Temperature of Engine Oil'. This provides a measure of an oils' ability to flow to the engine oil pump inlet and provide adequate engine oil pressure during the initial stages of operation.
Oils without the letter W, intended for use at higher temperatures, are based on the viscosity at 100°C only. These are measured by ASTM D445 'Method of Test for Kinematic Viscosity of temperature and Opaque Liquids'.
A 'Multi-grade' oil is one whose low temperature viscosity and borderline temperature satisfy the requirements of one of the W grades and whose viscosity at 100°C is within the stipulated range of one-W-grades.

Automotive Lubricant Viscosity Grades[1]
Engine Oils – SAE J 300, June 2001 (Dec. 1999)

SAE Viscosity Grade	Viscosity (cP) At Temp (°C), Max		Viscosity[4] (cSt) at 100°C		High-Shear Viscosity[5] (cP) at 150°C and 10sec^{-1}, Min
	Cranking[2]	Pumping[3]	Min	Max	
0W	6200 at -35	60,000 at -40	3.8		
5W	6600 at -30	60,000 at -35	3.8		
10W	7000 at -25	60,000 at -30	4.1		
15W	7000 at -20	60,000 at -25	5.6		
20W	9500 at -15	60,000 at -20	5.6		
25W	135000 at -10	60,000 at -15	9.3		
20			5.6	<9.3	2.6
30			9.3	<12.3	2.9
40			12.5	<16.3	2.9[6]
40			12.5	<16.3	3.7[7]
50			16.3	<21.9	3.7
60			21.9	<26.1	3.7

[1]All values are critical specifications as defined by ASTM D3244
[2]ASTM D5293
[3]ASTM D4684. Note that the presence of any yield stress detectable by this method constitutes a failure regardless of viscosity.
[4]ASTM D445
[5]ASTM D4683, CEC L-36-A-90 (ASTM D 4741) or ASTM DS481
[6]0W-40, 5W-40 & 10W-40 grades
[7]15W-40, 20W-40, 25W-40 & 40grades

AUTOMOTIVE GEAR LUBRICANT CLASSIFICATIONS

SAE J306 (Gear Oils)

Again, 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 noticed 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 widely different SAE grade designation as defined in the two classifications.

Automotive Lubricant Viscosity Grades

Gear Oils – Except SAE J 306, 1998

SAE VISCOSITY GRADE	ASTM D2983 TEMPERATURE °C FOR VISCOSITY OF 150000mPa.S[(1)]	ASTM D445(mm^2/s) VISCOSITY AT 100°C	
	MAX	**MIN**[2]	**MAX**
70W	-55[3]	4.1	-
75W	-40	4.1	-
80W	-26	7.0	-
85W	-12	11.0	-
80		7.0	<11.0
85		11.0	<13.0
90		13.5	<24.0
140		24.0	<41.0
250		41.0	-

[1]Using ASTM D 2983, additional low temperature viscosity requirements may be appropriate for fluids intended for use in light-duty synchronised manual transmission.

[2]Limit must also be met after testing in CEC l-45-T-93, Method C (20 hours)

[3] The precision of ASTM D 2983 has not been established for determinations made at temperatures below –40 C. This fact should be taken into consideration in any producer-consumer relationship.

Note: 1cP = 1 mPa.s; 1cSt = 1mm^2/s

ISO Viscosity Grades

Viscosity System for Industrial Lubricants

ISO Grade	Mid-Point Viscosity cSt. @ 40°C	Viscosity, cSt @ 40°C	
		Minimum	Maximum
2	2.2	1.98	2.42
3	3.2	2.88	3.52
5	4.6	4.14	5.06
7	6.8	6.12	7.48
10	10	9.00	11.0
15	15	13.5	16.5
22	22	19.8	24.2
32	32	28.8	35.2
46	46	41.4	50.6
68	68	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

Approximate Comparison of Different Viscosity Scales

The following table is for the conversion of viscosities in one system to those in another system at the same temperature.

Kinematic Viscosity cSt	Engler Degrees	Redwood No.1 Seconds	Saybolt Universal Seconds	Kinematic Viscosity cSt	Engler Degrees	Redwood No.1 Seconds	Saybolt Universal Seconds
1.0	1.0	28.5	-	20.0	2.9	86	97.5
1.5	1.06	30	-	20.5	2.95	88	99.6
2.0	1.12	31	32.6	21.0	3.0	90	101.7
2.5	1.17	32	34.4	21.5	3.05	92	103.9
3.0	1.22	33	36.0	22.0	3.1	93	106.0
3.5	1.16	34.5	37.6	22.5	3.15	95	108.2
4.0	1.30	35.5	39.1	23.0	3.2	97	110.3
4.5	1.35	37	40.7	23.5	3.3	99	112.4
5.0	1.40	38	42.3	24.0	3.35	101	114.6
*5.5	1.44	39.5	43.9	24.5	3.4	103	116.8
*6.0	1.48	41	45.5	25.0	3.45	105	118.9
*6.5	1.52	42	47.1	26.0	3.6	109	123.2
*7.0	1.56	43.5	48.7	27.0	3.7	113	127.7

Kinematic Viscosity cSt	Engler Degrees	Redwood No.1 Seconds	Saybolt Universal Seconds	Kinematic Viscosity cSt	Engler Degrees	Redwood No.1 Seconds	Saybolt Universal Seconds
*7.5	1.60	45	50.3	28.0	3.85	117	132.1
*8.0	1.65	46	52.0	29.0	3.95	121	136.5
*8.5	1.70	47.5	53.7	30.0	4.1	125	140.9
*9.0	1.75	49	55.4	31.0	4.2	129	145.3
*9.5	1.79	50.5	57.1	32.0	4.35	133	140.7
10.0	1.83	52	58.8	33.0	4.45	136	154.2
10.2	1.85	52.5	59.5	34.0	4.6	140	158.7
10.4	1.87	53	60.2	35.0	4.7	144	163.2
10.6	1.89	53.5	60.9	36.0	4.85	148	167.7
10.8	1.91	54.5	61.6	37.0	4.95	152	172.2
11.0	1.93	55	62.3	38.0	5.1	156	176.7
11.4	1.97	56	63.7	39.0	5.2	160	181.2
11.8	2.00	57.5	65.2	40.0	5.35	164	185.7
12.2	2.04	59	66.6	41.0	5.45	168	190.2
12.6	2.08	60	68.1	42.0	5.6	172	194.7
13.0	2.12	61	69.6	43.0	5.75	177	199.2
13.5	2.17	63	71.5	440	5.85	181	203.8
14.0	2.22	64.5	73.4	45.0	6.0	185	208.4
14.5	2.27	66	75.3	46.0	6.1	189	213.0
15.0	2.32	68	77.2	47.0	6.25	193	217.6
15.5	2.38	70	79.2	48.0	6.45	197	222.2
16.0	2.43	71.5	81.1	49.0	6.5	201	226.8
16.5	2.5	73	83.1	50.0	6.65	205	231.4
17.0	2.55	75	85.1	52.0	6.9	213	240.6
17.5	2.6	77	87.1	54.0	7.1	221	249.6
18.0	2.65	78.5	89.2	56.0	7.4	229	259.0
18.5	2.7	80	91.2	58.0	7.65	237	268.2
19.0	2.75	82	93.3	60.0	7.9	245	277.4
19.5	2.8	84	95.4	70.0	9.2	285	323.4

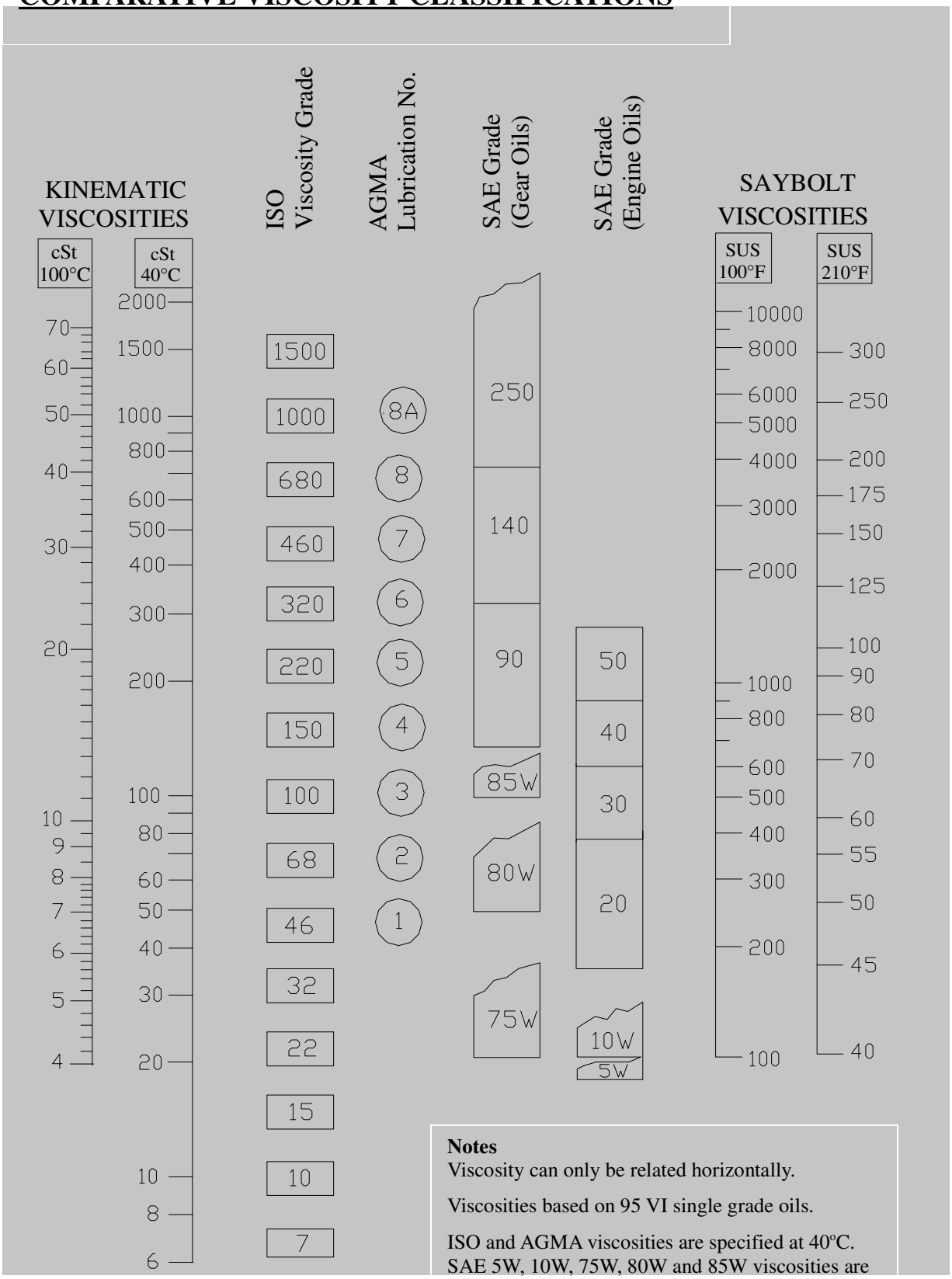
For higher viscosities, the following factors should be used.

Kinematic	= 0.247	Redwood	Saybolt	= 35.11	Engler
Engler	= 0.132	Kinematic	Engler	= 0.0326	Redwood
Redwood	= 4.05	Kinematic	Saybolt	= 1.14	Redwood
Saybolt	= 4.62	Kinematic	Kinematic	= 0.216	Saybolt
Kinematic	= 7.58	Engler	Engler	= 0.0285	Saybolt
Redwood	= 30.70	Engler	Redwood	= 0.887	Saybolt

Note:

The first part of the table mark with an * should only be used for the conversion of kinematic viscosities into Engler, Redwood or Saybolt viscosities, or for Engler, Redwood and Saybolt between themselves. They should not be used for conversion of Engler, Redwood or Saybolt into Kinematic viscosities.

COMPARATIVE VISCOSITY CLASSIFICATIONS



Notes

Viscosity can only be related horizontally.

Viscosities based on 95 VI single grade oils.

ISO and AGMA viscosities are specified at 40ºC. SAE 5W, 10W, 75W, 80W and 85W viscosities are specified at low temperature. Equivalent viscosities at 100ºF and 210ºF are shown.

SAE 90-250 (Gear Oils) and SAE 20-50 (Engine oils) are specified at 210oF/99oC.