Designation: D2270 – 04

British Standard 4459

Designation: 226/91 (95)

Standard Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 and 100°C[1]

This standard is issued under the fixed designation D2270; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice[2] covers the procedures for calculating the viscosity index of petroleum products, such as lubricating oils, and related materials from their kinematic viscosities at 40 and 100°C.

NOTE 1—The results obtained from the calculation of *VI* from kinematic viscosities determined at 40 and 100°C are virtually the same as those obtained from the former *VI* system using kinematic viscosities determined at 37.78 and 98.89°C.

1.1.1 *Procedure A*—For petroleum products of viscosity index up to and including 100.

1.1.2 *Procedure B*—For petroleum products of which the viscosity index is 100 or greater.

1.2 This standard does not apply to petroleum products with kinematic viscosities less than 2.0 mm^2/s (cSt) at 100°C. Table 1 given in this practice applies to petroleum products with kinematic viscosities between 2 and 70 mm^2/s (cSt) at 100°C. Equations are provided for calculating viscosity index for petroleum products having kinematic viscosities above 70 mm^2/s (cSt) at 100°C.

NOTE 2—1 cSt = 1 $mm^2/s = 10^{-6} m^2/s$.

1.2.1 In cases where kinematic viscosity data are not available at temperatures of 40 and 100°C, an estimate may be made of the viscosity index by calculating the kinematic viscosity at temperatures of 40 and 100°C from data obtained at other temperatures. Such viscosity index data may be considered as suitable for information only and not for specification purposes. See Test Method D341, Annex A1.

1.3 The kinematic viscosity values are determined with reference to a value of 1.0034 mm^2/s (cSt) at 20.00°C for distilled water. The determination of the kinematic viscosity of a petroleum product shall be carried out in accordance with Test Methods D445, IP 71, ISO 3104, or ISO 2909.

1.4 The values stated in SI units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D341 Test Method for Viscosity-Temperature Charts for Liquid Petroleum Products

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D1695 Terminology of Cellulose and Cellulose Derivatives

2.2 *ISO Standards:*

ISO 2909 Petroleum Products—Calculation of Viscosity Index from Kinematic Viscosity[4]

ISO 3104 Petroleum Products—Transparent and Opaque

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.07 on Flow Properties.

In the IP, this practice is under the jurisdiction of the Standardization Committee and issued under the fixed designation IP 226. The final number indicates the year of last revision.

Current edition approved Nov. 1, 2004. Published November 2004. Originally approved in 1964. Last previous edition approved in 1998 as D2270–93(1998). DOI: 10.1520/D2270-04.

[2] Supporting data (Metrication of Viscosity Index System Method D2270) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report D02-1009.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

TABLE 1 Basic Values for *L* and *H* for Kinematic Viscosity in 40 to 100°C System

Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*	Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*	Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*	Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*	Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*	Kinematic Viscosity at 100°C, mm^2/s (cSt)	*L*	*H*
2.00	7.994	6.394	7.00	78.00	48.57	12.0	201.9	108.0	17.0	369.4	180.2	24.0	683.9	301.8	42.5	1935	714.9
2.10	8.640	6.894	7.10	80.25	49.61	12.1	204.8	109.4	17.1	373.3	181.7	24.2	694.5	305.6	43.0	1978	728.2
2.20	9.309	7.410	7.20	82.39	50.69	12.2	207.8	110.7	17.2	377.1	183.3	24.4	704.2	309.4	43.5	2021	741.3
2.30	10.00	7.944	7.30	84.53	51.78	12.3	210.7	112.0	17.3	381.0	184.9	24.6	714.9	313.0	44.0	2064	754.4
2.40	10.71	8.496	7.40	86.66	52.88	12.4	213.6	113.3	17.4	384.9	186.5	24.8	725.7	317.0	44.5	2108	767.6
2.50	11.45	9.063	7.50	88.85	53.98	12.5	216.6	114.7	17.5	388.9	188.1	25.0	736.5	320.9	45.0	2152	780.9
2.60	12.21	9.647	7.60	91.04	55.09	12.6	219.6	116.0	17.6	392.7	189.7	25.2	747.2	324.9	45.5	2197	794.5
2.70	13.00	10.25	7.70	93.20	56.20	12.7	222.6	117.4	17.7	396.7	191.3	25.4	758.2	328.8	46.0	2243	808.2
2.80	13.80	10.87	7.80	95.43	57.31	12.8	225.7	118.7	17.8	400.7	192.9	25.6	769.3	332.7	46.5	2288	821.9
2.90	14.63	11.50	7.90	97.72	58.45	12.9	228.8	120.1	17.9	404.6	194.6	25.8	779.7	336.7	47.0	2333	835.5
3.00	15.49	12.15	8.00	100.0	59.60	13.0	231.9	121.5	18.0	408.6	196.2	26.0	790.4	340.5	47.5	2380	849.2
3.10	16.36	12.82	8.10	102.3	60.74	13.1	235.0	122.9	18.1	412.6	197.8	26.2	801.6	344.4	48.0	2426	863.0
3.20	17.26	13.51	8.20	104.6	61.89	13.2	238.1	124.2	18.2	416.7	199.4	26.4	812.8	348.4	48.5	2473	876.9
3.30	18.18	14.21	8.30	106.9	63.05	13.3	241.2	125.6	18.3	420.7	201.0	26.6	824.1	352.3	49.0	2521	890.9
3.40	19.12	14.93	8.40	109.2	64.18	13.4	244.3	127.0	18.4	424.9	202.6	26.8	835.5	356.4	49.5	2570	905.3
3.50	20.09	15.66	8.50	111.5	65.32	13.5	247.4	128.4	18.5	429.0	204.3	27.0	847.0	360.5	50.0	2618	919.6
3.60	21.08	16.42	8.60	113.9	66.48	13.6	250.6	129.8	18.6	433.2	205.9	27.2	857.5	364.6	50.5	2667	933.6
3.70	22.09	17.19	8.70	116.2	67.64	13.7	253.8	131.2	18.7	437.3	207.6	27.4	869.0	368.3	51.0	2717	948.2
3.80	23.13	17.97	8.80	118.5	68.79	13.8	257.0	132.6	18.8	441.5	209.3	27.6	880.6	372.3	51.5	2767	962.9
3.90	24.19	18.77	8.90	120.9	69.94	13.9	260.1	134.0	18.9	445.7	211.0	27.8	892.3	376.4	52.0	2817	977.5
4.00	25.32	19.56	9.00	123.3	71.10	14.0	263.3	135.4	19.0	449.9	212.7	28.0	904.1	380.6	52.5	2867	992.1
4.10	26.50	20.37	9.10	125.7	72.27	14.1	266.6	136.8	19.1	454.2	214.4	28.2	915.8	384.6	53.0	2918	1007
4.20	27.75	21.21	9.20	128.0	73.42	14.2	269.8	138.2	19.2	458.4	216.1	28.4	927.6	388.8	53.5	2969	1021
4.30	29.07	22.05	9.30	130.4	74.57	14.3	273.0	139.6	19.3	462.7	217.7	28.6	938.6	393.0	54.0	3020	1036
4.40	30.48	22.92	9.40	132.8	75.73	14.4	276.3	141.0	19.4	467.0	219.4	28.8	951.2	396.6	54.5	3073	1051
4.50	31.96	23.81	9.50	135.3	76.91	14.5	279.6	142.4	19.5	471.3	221.1	29.0	963.4	401.1	55.0	3126	1066
4.60	33.52	24.71	9.60	137.7	78.08	14.6	283.0	143.9	19.6	475.7	222.8	29.2	975.4	405.3	55.5	3180	1082
4.70	35.13	25.63	9.70	140.1	79.27	14.7	286.4	145.3	19.7	479.7	224.5	29.4	987.1	409.5	56.0	3233	1097
4.80	36.79	26.57	9.80	142.7	80.46	14.8	289.7	146.8	19.8	483.9	226.2	29.6	998.9	413.5	56.5	3286	1112
4.90	38.50	27.53	9.90	145.2	81.67	14.9	293.0	148.2	19.9	488.6	227.7	29.8	1011	417.6	57.0	3340	1127
5.00	40.23	28.49	10.0	147.7	82.87	15.0	296.5	149.7	20.0	493.2	229.5	30.0	1023	421.7	57.5	3396	1143
5.10	41.99	29.46	10.1	150.3	84.08	15.1	300.0	151.2	20.2	501.5	233.0	30.5	1055	432.4	58.0	3452	1159
5.20	43.76	30.43	10.2	152.9	85.30	15.2	303.4	152.6	20.4	510.8	236.4	31.0	1086	443.2	58.5	3507	1175
5.30	45.53	31.40	10.3	155.4	86.51	15.3	306.9	154.1	20.6	519.9	240.1	31.5	1119	454.0	59.0	3563	1190
5.40	47.31	32.37	10.4	158.0	87.72	15.4	310.3	155.6	20.8	528.8	243.5	32.0	1151	464.9	59.5	3619	1206
5.50	49.09	33.34	10.5	160.6	88.95	15.5	313.9	157.0	21.0	538.4	247.1	32.5	1184	475.9	60.0	3676	1222
5.60	50.87	34.32	10.6	163.2	90.19	15.6	317.5	158.6	21.2	547.5	250.7	33.0	1217	487.0	60.5	3734	1238
5.70	52.64	35.29	10.7	165.8	91.40	15.7	321.1	160.1	21.4	556.7	254.2	33.5	1251	498.1	61.0	3792	1254
5.80	54.42	36.26	10.8	168.5	92.65	15.8	324.6	161.6	21.6	566.4	257.8	34.0	1286	509.6	61.5	3850	1270
5.90	56.20	37.23	10.9	171.2	93.92	15.9	328.3	163.1	21.8	575.6	261.5	34.5	1321	521.1	62.0	3908	1286
6.00	57.97	38.19	11.0	173.9	95.19	16.0	331.9	164.6	22.0	585.2	264.9	35.0	1356	532.5	62.5	3966	1303
6.10	59.74	39.17	11.1	176.6	96.45	16.1	335.5	166.1	22.2	595.0	268.6	35.5	1391	544.0	63.0	4026	1319
6.20	61.52	40.15	11.2	179.4	97.71	16.2	339.2	167.7	22.4	604.3	272.3	36.0	1427	555.6	63.5	4087	1336
6.30	63.32	41.13	11.3	182.1	98.97	16.3	342.9	169.2	22.6	614.2	275.8	36.5	1464	567.1	64.0	4147	1352
6.40	65.18	42.14	11.4	184.9	100.2	16.4	346.6	170.7	22.8	624.1	279.6	37.0	1501	579.3	64.5	4207	1369
6.50	67.12	43.18	11.5	187.6	101.5	16.5	350.3	172.3	23.0	633.6	283.3	37.5	1538	591.3	65.0	4268	1386
6.60	69.16	44.24	11.6	190.4	102.8	16.6	354.1	173.8	23.2	643.4	286.8	38.0	1575	603.1	65.5	4329	1402
6.70	71.29	45.33	11.7	193.3	104.1	16.7	358.0	175.4	23.4	653.8	290.5	38.5	1613	615.0	66.0	4392	1419
6.80	73.48	46.44	11.8	196.2	105.4	16.8	361.7	177.0	23.6	663.3	294.4	39.0	1651	627.1	66.5	4455	1436
6.90	75.72	47.51	11.9	199.0	106.7	16.9	365.6	178.6	23.8	673.7	297.9	39.5	1691	639.2	67.0	4517	1454
												40.0	1730	651.8	67.5	4580	1471
												40.5	1770	664.2	68.0	4645	1488
												41.0	1810	676.6	68.5	4709	1506
												41.5	1851	689.1	69.0	4773	1523
												42.0	1892	701.9	69.5	4839	1541
															70.0	4905	1558

Liquids—Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity[4]

2.3 *Energy Institute Standard:*

IP 71 Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *viscosity index, n*—an arbitrary number used to characterize the variation of the kinematic viscosity of a petroleum product with temperature.

3.1.1.1 *Discussion*—For oils of similar kinematic viscosity, the higher the viscosity index the smaller the effect of temperature on its kinematic viscosity.

3.1.1.2 *Discussion*—Viscosity index is also used in Terminology D1695 in a definition unrelated to this one.

4. Significance and Use

4.1 The viscosity index is a widely used and accepted measure of the variation in kinematic viscosity due to changes in the temperature of a petroleum product between 40 and 100°C.

4.2 A higher viscosity index indicates a smaller decrease in kinematic viscosity with increasing temperature of the lubricant.

4.3 The viscosity index is used in practice as a single number indicating temperature dependence of kinematic viscosity.

5. Procedure A—Oils of Viscosity Index Up to and Including 100

5.1 Determine the kinematic viscosity of the sample at 40 and 100°C in accordance with Test Method D445, ISO 3104, or IP 71.

5.2 *Calculation*:

5.2.1 If the kinematic viscosity of the oils at 100°C is less than or equal to 70 mm²/s (cSt), extract from Table 1 the corresponding values for *L* and *H*. Measured values that are not listed, but are within the range of Table 1, may be obtained by linear interpolation. The viscosity index is not defined and may not be reported for oils of kinematic viscosity of less than 2.0 mm²/s (cSt) at 100°C.

5.2.2 If the kinematic viscosity is above 70 mm²/s (cSt) at 100°C, calculate the values of *L* and *H* as follows:

$$L = 0.8353\, Y^2 + 14.67\, Y - 216 \tag{1}$$

$$H = 0.1684\, Y^2 + 11.85\, Y - 97 \tag{2}$$

where:

L = kinematic viscosity at 40°C of an oil of 0 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated, mm²/s (cSt),

Y = kinematic viscosity at 100°C of the oil whose viscosity index is to be calculated, mm²/s (cSt), and

H = kinematic viscosity at 40°C of an oil of 100 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated mm²/s (cSt).

5.2.3 Calculate the viscosity index, *VI*, of the oil as follows:

$$VI = [(L - U)/(L - H)] \times 100 \tag{3}$$

where:

U = kinematic viscosity at 40°C of the oil whose viscosity index is to be calculated mm²/s (cSt).

5.2.4 *Calculation Example*—Measured kinematic viscosity at 40°C of the oil whose viscosity index is to be calculated = 73.30 mm²/s (cSt); kinematic viscosity at 100°C of the oil whose viscosity index is to be calculated = 8.86 mm²/s (cSt):

From Table 1 (by interpolation) L = 119.94

From Table 1 (by interpolation) H = 69.48

Substituting in Eq 3 and rounding to the nearest whole number:

$$VI = [(119.94 - 73.30)/(119.94 - 69.48)] \times 100 = 92.43 \tag{4}$$

$$VI = 92 \tag{5}$$

5.3 *ASTM DS 39b, Viscosity Index Tables for Celsius Temperatures*, [3] is based on the above calculation and may be used instead of 5.2-5.2.4.

6. Procedure B—Oils of Viscosity Index of 100 and Greater

6.1 Determine the kinematic viscosity of the sample at 40 and 100°C in accordance with Test Method D445, ISO 3104, or IP 71.

6.2 *Calculation*:

6.2.1 If the kinematic viscosity of the oil at 100°C is in the range of 2 to 70 mm²/s (cSt), extract the corresponding value for *H* from Table 1. Measured values that are not listed, but are within the range of Table 1, can be obtained by linear interpolation. The viscosity index is not defined and may not be reported for oils of kinematic viscosity of less than 2.0 mm²/s (cSt) at 100°C.

6.2.2 If the measured kinematic viscosity at 100°C is greater than 70 mm²/s (cSt), calculate the value of *H* as follows:

$$H = 0.1684\, Y^2 + 11.85\, Y - 97 \tag{6}$$

where:

Y = kinematic viscosity at 100°C of the oil whose kinematic viscosity is to be calculated, mm²/s (cSt), and

H = kinematic viscosity at 40°C of an oil of 100 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated mm²/s (cSt).

6.2.3 Calculate the viscosity index, *VI*, of the oil as follows:

$$VI = [((\text{antilog } N) - 1)/0.00715] + 100 \tag{7}$$

where:

$$N = (\log H - \log U)/ \log Y, \tag{8}$$

or

$$Y^N = H/U \tag{9}$$

[5] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K.