International Standard 2909

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Petroleum products — Calculation of viscosity index from kinematic viscosity

Produits pétroliers — Calcul de l'indice de viscosité à partir de la viscosité cinématique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2909 was developed by Technical Committee ISO/TC 28, *Petroleum products and lubricants.*

This second edition was submitted directly to the ISO Council, in accordance with clause 5.10.1 of part 1 of the Directives for the technical work of ISO. It cancels and replaces the first edition (i.e. ISO 2909-1975), which had been approved by the member bodies of the following countries :

Australia	Hungary	Spain
Austria	India	Sweden
Belgium	Iran	Thailand
Bulgaria	Israel	Turkey
Canada	Japan	United Kingdom
Chile	Netherlands	USA
Czechoslovakia	Norway	USSR
France	Romania	
Germany, F. R.	South Africa, Rep. of	

No member body had expressed disapproval of the document.

Petroleum products — Calculation of viscosity index from kinematic viscosity

1 Scope and field of application

1.1 This International Standard specifies two procedures for calculating the viscosity index of petroleum products and related materials from their kinematic viscosities at 40 °C and 100 °C * :

— Procedure A is applicable to petroleum products of viscosity index up to and including 100;

— Procedure B is applicable to petroleum products of viscosity index 100 or greater.

1.2 The table given in this International Standard applies to petroleum products with kinematic viscosities between 2 and 70 mm^2/s at 100 °C **. Equations are provided for calculating viscosity index for petroleum products having kinematic viscosities above 70 mm^2/s at 100 °C.

1.3 The kinematic viscosity values are determined with reference to a value of 1,003 8 mm^2/s at 20,00 °C for distilled water. The determination of the kinematic viscosity of a petroleum product shall be carried out in accordance with ISO 3104.

2 Reference

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity.*

3 Definition

viscosity index (VI) : A number on a conventional scale used to characterize the variation of the viscosity of a petroleum product with temperature. A high viscosity index indicates a relatively small change of viscosity with temperature and vice versa.

4 Procedure A

(For petroleum products of viscosity index up to and including 100.)

4.1 Calculation

4.1.1 If the kinematic viscosity of the petroleum product at 100 °C is less than or equal to 70 mm^2/s, extract from the table the corresponding values for L and D. Measured values which are not listed, but which are within the range of the table, may be obtained by linear interpolation.

4.1.2 If the kinematic viscosity is above 70 mm^2/s at 100 °C, calculate the values of L and D as follows :

$$L = 0{,}835\,3\,Y^2 + 14{,}67\,Y - 216 \quad \ldots(1)$$

$$D = 0{,}666\,9\,Y^2 + 2{,}82\,Y - 119 \quad \ldots(2)$$

where

L is the kinematic viscosity, in square millimetres per second, at 40 °C of a petroleum product of viscosity index 0 having the same kinematic viscosity at 100 °C as the petroleum product whose viscosity index is to be calculated;

Y is the kinematic viscosity, in square millimetres per second, at 100 °C of the petroleum product whose viscosity index is to be calculated;

$D = L - H$;

H being the kinematic viscosity, in square millimetres per second, at 40 °C of a petroleum product of viscosity index 100 having the same kinematic viscosity at 100 °C as the petroleum product whose viscosity index is to be calculated.

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* The results obtained from the calculation of VI from kinematic viscosities determined at 40 °C and 100 °C are virtually the same as those obtained from the former VI system using kinematic viscosities determined at 37,78 °C and 98,89 °C.

** In this International Standard, kinematic viscosity is expressed in square millimetres per second (mm^2/s), which is a recommended sub-multiple of the SI unit (m^2/s) for this quantity. In practice, however, the centistoke (cSt) is generally used in this case in the petroleum and petrochemical industries. The values of the kinematic viscosity are unaffected by this practice in view of the fact that 1 cSt = 1 mm^2/s.

4.1.3 Calculate the viscosity index VI of the petroleum product as follows :

$$VI = \frac{L - U}{L - H} \times 100 \qquad ...(3)$$

$$VI = \frac{L - U}{D} \times 100 \qquad ...(4)$$

where

U is the kinematic viscosity, in square millimetres per second, at 40 °C of the petroleum product whose viscosity index is to be calculated;

$D = L - H$.

4.1.4 Example of calculation :

Measured kinematic viscosity at 40 °C of the petroleum product whose viscosity index is to be calculated = 73,30 mm^2/s; kinematic viscosity at 100 °C of the petroleum product whose viscosity index is to be calculated = 8,86 mm^2/s.

From the table (by interpolation) L = 119,94

From the table (by interpolation) D = 50,476

Substituting in equation (4) and rounding to the nearest whole number :

$$VI = \frac{119,94 - 73,30}{50,476} \times 100 = 92,40$$

VI = 92

NOTE — When the number is exactly halfway between the nearest two whole numbers, round it to the nearest even number. For example, 89,5 should be reported as 90.

4.2 Expression of results

Express the results as the viscosity index, VI, to the nearest whole number.

4.3 Precision

The precision of a viscosity index value depends on the precision of the two independent kinematic viscosity values from which it is derived. The results of two viscosity index calculations shall be considered suspect if the values of the kinematic viscosities differ by more than the amounts quoted for repeatability or reproducibility as given in ISO 3104. The precision levels given in the following table are based entirely on the precision levels given in ISO 3104.

Kinematic viscosity at 100 °C mm^2/s	Precision			
	VI = 0		VI = 100	
	Repeatability	Reproducibility	Repeatability	Reproducibility
4	2,4	4,8	1,7	3,4
6	2,1	4,2	1,3	2,6
8	1,9	3,7	1,1	2,2
15	1,5	3,0	0,7	1,4
30	1,2	2,5	0,4	0,9
50	1,1	2,2	0,3	0,7

The precision number for any kinematic viscosity or VI value may be calculated with sufficient accuracy by performing linear interpolations.

The repeatabilities and reproducibilities given are for a probability level of 95 %.

4.4 Test report

The test report shall contain at least the following information :

a) the type and identification of the product tested;

b) a reference to this International Standard or to a corresponding national standard;

c) the result of the test;

d) whether procedure A or B was used;

e) any deviation, by agreement or otherwise, from the procedure specified;

f) the date of the test.

Table — Measured values of L, D and H for kinematic viscosity

Kinematic viscosity at 100 °C mm^2/s	L	$D = (L - H)$	H
2,00	7,994	1,600	6,394
2,10	8,640	1,746	6,894
2,20	9,309	1,898	7,410
2,30	10,00	2,056	7,944
2,40	10,71	2,219	8,496
2,50	11,45	2,390	9,063
2,60	12,21	2,567	9,647
2,70	13,00	2,748	10,25
2,80	13,80	2,937	10,87
2,90	14,63	3,132	11,50
3,00	15,49	3,334	12,15
3,10	16,36	3,540	12,82
3,20	17,26	3,753	13,51
3,30	18,18	3,971	14,21
3,40	19,12	4,196	14,93
3,50	20,09	4,428	15,66
3,60	21,08	4,665	16,42
3,70	22,09	4,909	17,19
3,80	23,13	5,157	17,97
3,90	24,19	5,415	18,77
4,00	25,32	5,756	19,56
4,10	26,50	6,129	20,37
4,20	27,75	6,546	21,21
4,30	29,07	7,017	22,05
4,40	30,48	7,560	22,92
4,50	31,96	8,156	23,81
4,60	33,52	8,806	24,71
4,70	35,13	9,499	25,63
4,80	36,79	10,22	26,57
4,90	38,50	10,97	27,53
5,00	40,23	11,74	28,49
5,10	41,99	12,53	29,46
5,20	43,76	13,32	30,43
5,30	45,53	14,13	31,40
5,40	47,31	14,94	32,37
5,50	49,09	15,75	33,34
5,60	50,87	16,55	34,32
5,70	52,64	17,36	35,29
5,80	54,42	18,16	36,26
5,90	56,20	18,97	37,23
6,00	57,97	19,78	38,19
6,10	59,74	20,57	39,17
6,20	61,52	21,38	40,15
6,30	63,32	22,19	41,13
6,40	65,18	23,03	42,14
6,50	67,12	23,94	43,18
6,60	69,16	24,92	44,24
6,70	71,29	25,96	45,33
6,80	73,48	27,04	46,44
6,90	75,72	28,21	47,51
7,00	78,00	29,43	48,57
7,10	80,25	30,63	49,61
7,20	82,39	31,70	50,69
7,30	84,53	32,74	51,78
7,40	86,66	33,79	52,88
7,50	88,85	34,87	53,98
7,60	91,04	35,94	55,09
7,70	93,20	37,01	56,20
7,80	95,43	38,12	57,31
7,90	97,72	39,27	58,45
8,00	100,0	40,40	59,60
8,10	102,3	41,57	60,74
8,20	104,6	42,72	61,89
8,30	106,9	43,85	63,05
8,40	109,2	45,01	64,18
8,50	111,5	46,19	65,32
8,60	113,9	47,40	66,48
8,70	116,2	48,57	67,64
8,80	118,5	49,75	68,79
8,90	120,9	50,96	69,94
9,00	123,3	52,20	71,10
9,10	125,7	53,40	72,27
9,20	128,0	54,61	73,42
9,30	130,4	55,84	74,57
9,40	132,8	57,10	75,73
9,50	135,3	58,36	76,91
9,60	137,7	59,60	78,08
9,70	140,1	60,87	79,27
9,80	142,7	62,22	80,46
9,90	145,2	63,54	81,67
10,0	147,7	64,86	82,87
10,1	150,3	66,22	84,08
10,2	152,9	67,56	85,30
10,3	155,4	68,90	86,51
10,4	158,0	70,25	87,72
10,5	160,6	71,63	88,95
10,6	163,2	73,00	90,19
10,7	165,8	74,42	91,40
10,8	168,5	75,86	92,65
10,9	171,2	77,33	93,92
10,0	173,9	78,75	95,19
11,1	176,6	80,20	96,45
11,2	179,4	81,65	97,71
11,3	182,1	83,13	98,97
11,4	184,9	84,63	100,2
11,5	187,6	86,10	101,5
11,6	190,4	87,61	102,8
11,7	193,3	89,18	104,1
11,8	196,2	90,75	105,4
11,9	199,0	92,30	106,7
12,0	201,9	93,87	108,0
12,1	204,8	95,47	109,4
12,2	207,8	97,07	110,7
12,3	210,7	98,66	112,0
12,4	213,6	100,3	113,3
12,5	216,6	101,9	114,7
12,6	219,6	103,6	116,0
12,7	222,6	105,3	117,4
12,8	225,7	107,0	118,7
12,9	228,8	108,7	120,1

Table — Measured values of L, D and H for kinematic viscosity *(continued)*

Kinematic viscosity at 100 °C mm²/s	L	$D = (L - H)$	H
13,0	231,9	110,4	121,5
13,1	235,0	112,1	122,9
13,2	238,1	113,8	124,2
13,3	241,2	115,6	125,6
13,4	244,3	117,3	127,0
13,5	247,4	119,0	128,4
13,6	250,6	120,8	129,8
13,7	253,8	122,6	131,2
13,8	257,0	124,4	132,6
13,9	260,1	126,2	134,0
14,0	263,3	128,0	135,4
14,1	266,6	129,8	136,8
14,2	269,8	131,6	138,2
14,3	273,0	133,5	139,6
14,4	276,3	135,3	141,0
14,5	279,6	137,2	142,4
14,6	283,0	139,1	143,9
14,7	286,4	141,1	145,3
14,8	289,7	142,9	146,8
14,9	293,0	144,8	148,2
15,0	296,5	146,8	149,7
15,1	300,0	148,8	151,2
15,2	303,4	150,8	152,6
15,3	306,9	152,8	154,1
15,4	310,3	154,8	155,6
15,5	313,9	156,9	157,0
15,6	317,5	158,9	158,6
15,7	321,1	161,0	160,1
15,8	324,6	163,0	161,6
15,9	328,3	165,2	163,1
16,0	331,9	167,3	164,6
16,1	335,5	169,4	166,1
16,2	339,2	171,5	167,7
16,3	342,9	173,7	169,2
16,4	346,6	175,8	170,7
16,5	350,3	178,1	172,3
16,6	354,1	180,3	173,8
16,7	358,0	182,5	175,4
16,8	361,7	184,7	177,0
16,9	365,6	187,0	178,6
17,0	369,4	189,2	180,2
17,1	373,3	191,5	181,7
17,2	377,1	193,8	183,3
17,3	381,0	196,1	184,9
17,4	384,9	198,4	186,5
17,5	388,9	200,8	188,1
17,6	392,7	203,0	189,7
17,7	396,7	205,3	191,3
17,8	400,7	207,7	192,9
17,9	404,6	210,0	194,6
18,0	408,6	212,4	196,2
18,1	412,6	214,8	197,8
18,2	416,7	217,3	199,4
18,3	420,7	219,7	201,0
18,4	424,9	222,2	202,6
18,5	429,0	224,7	204,3
18,6	433,2	227,2	205,9
18,7	437,3	229,7	207,6
18,8	441,5	232,3	209,3
18,9	445,7	234,7	211,0
19,0	449,9	237,3	212,7
19,1	454,2	239,8	214,4
19,2	458,4	242,3	216,1
19,3	462,7	245,0	217,7
19,4	467,0	247,6	219,4
19,5	471,3	250,2	221,1
19,6	475,7	252,9	222,8
19,7	479,7	255,2	224,5
19,8	483,9	257,8	226,2
19,9	488,6	260,9	227,7
20,0	493,2	263,7	229,5
20,2	501,5	268,5	233,0
20,4	510,8	274,4	236,4
20,6	519,9	279,8	240,1
20,8	528,8	285,3	243,5
21,0	538,4	291,3	247,1
21,2	547,5	296,8	250,7
21,4	556,7	302,6	254,2
21,6	566,4	308,6	257,8
21,8	575,6	314,1	261,5
22,0	585,2	320,2	264,9
22,2	595,0	326,4	268,6
22,4	604,3	332,0	272,3
22,6	614,2	338,4	275,8
22,8	624,1	344,5	279,6
23,0	633,6	350,3	283,3
23,2	643,4	356,6	286,8
23,4	653,8	363,3	290,5
23,6	663,3	369,0	294,4
23,8	673,7	375,7	297,9
24,0	683,9	382,1	301,8
24,2	694,5	388,9	305,6
24,4	704,2	394,8	309,4
24,6	714,9	401,9	313,0
24,8	725,7	408,8	317,0
25,0	736,5	415,6	320,9
25,2	747,2	422,4	324,9
25,4	758,2	429,5	328,8
25,6	769,3	436,6	332,7
25,8	779,7	443,0	336,7
26,0	790,4	449,8	340,5
26,2	801,6	457,2	344,4
26,4	812,8	464,4	348,4
26,6	824,1	471,8	352,3
26,8	835,5	479,1	356,4
27,0	847,0	486,6	360,5
27,2	857,5	492,9	364,6
27,4	869,0	500,6	368,3
27,6	880,6	508,3	372,3
27,8	892,3	515,9	376,4

Table — Measured values of L, D and H for kinematic viscosity *(conclued)*

Kinematic viscosity at 100 °C mm²/s	L	$D = (L - H)$	H
28,0	904,1	523,5	380,6
28,2	915,8	531,2	384,6
28,4	927,6	538,8	388,8
28,6	938,6	545,7	393,0
28,8	951,2	554,5	396,6
29,0	963,4	562,3	401,1
29,2	975,4	570,1	405,3
29,4	987,1	577,6	409,5
29,6	998,9	585,3	413,5
29,8	1 011	593,4	417,6
30,0	1 023	601,6	421,7
30,5	1 055	622,3	432,4
31,0	1 086	643,2	443,2
31,5	1 119	664,5	454,0
32,0	1 151	686,0	464,9
32,5	1 184	708,0	475,9
33,0	1 217	730,2	487,0
33,5	1 251	752,8	498,1
34,0	1 286	776,8	509,6
34,5	1 321	799,9	521,1
35,0	1 356	823,4	532,5
35,5	1 391	847,2	544,0
36,0	1 427	871,2	555,6
36,5	1 464	896,5	567,1
37,0	1 501	921,8	579,3
37,5	1 538	946,8	591,3
38,0	1 575	972,3	603,1
38,5	1 613	998,3	615,0
39,0	1 651	1 024	627,1
39,5	1 691	1 052	639,2
40,0	1 730	1 079	651,8
40,5	1 770	1 106	664,2
41,0	1 810	1 133	676,6
41,5	1 851	1 162	689,1
42,0	1 892	1 191	701,9
42,5	1 935	1 220	714,9
43,0	1 978	1 250	728,2
43,5	2 021	1 280	741,3
44,0	2 064	1 310	754,4
44,5	2 108	1 340	767,6
45,0	2 152	1 371	780,9
45,5	2 197	1 403	794,5
46,0	2 243	1 434	808,2
46,5	2 288	1 466	821,9
47,0	2 333	1 498	835,5

Kinematic viscosity at 100 °C mm²/s	L	$D = (L - H)$	H
47,5	2 380	1 530	849,2
48,0	2 426	1 563	863,0
48,5	2 473	1 596	876,9
49,0	2 521	1 630	890,9
49,5	2 570	1 665	905,3
50,0	2 618	1 699	919,6
50,5	2 667	1 733	933,6
51,0	2 717	1 769	948,2
51,5	2 767	1 804	962,9
52,0	2 817	1 839	977,5
52,5	2 867	1 875	992,1
53,0	2 918	1 911	1 007
53,5	2 969	1 947	1 021
54,0	3 020	1 984	1 036
54,5	3 073	2 022	1 051
55,0	3 126	2 060	1 066
55,5	3 180	2 098	1 082
56,0	3 233	2 136	1 097
56,5	3 286	2 174	1 112
57,0	3 340	2 213	1 127
57,5	3 396	2 253	1 143
58,0	3 452	2 293	1 159
58,5	3 507	2 332	1 175
59,0	3 563	2 372	1 190
59,5	3 619	2 413	1 206
60,0	3 676	2 454	1 222
60,5	3 734	2 496	1 238
61,0	3 792	2 538	1 254
61,5	3 850	2 579	1 270
62,0	3 908	2 621	1 286
62,5	3 966	2 664	1 303
63,0	4 026	2 707	1 319
63,5	4 087	2 751	1 336
64,0	4 147	2 795	1 352
64,5	4 207	2 858	1 369
65,0	4 268	2 882	1 386
65,5	4 329	2 927	1 402
66,0	4 392	2 973	1 419
66,5	4 455	3 018	1 436
67,0	4 517	3 064	1 454
67,5	4 580	3 110	1 471
68,0	4 645	3 157	1 488
68,5	4 709	3 204	1 506
69,0	4 773	3 250	1 523
69,5	4 839	3 298	1 541
70,0	4 905	3 346	1 558

5 Procedure B

(For petroleum products of viscosity index 100 or greater.)

5.1 Calculation

5.1.1 Calculate the viscosity index from

$$VI = \left\{[(\text{antilog } N) - 1]/0{,}007\ 15\right\} + 100 \qquad ...(5)$$

$$N = (\log H - \log U)/\log Y \qquad ...(6)$$

where

U and Y are the measured kinematic viscosities at 40 °C and 100 °C, respectively, of the liquid whose viscosity index has to be found, while H is the kinematic viscosity at 40 °C of a liquid of viscosity index 100 which has the same kinematic viscosity at 100 °C as the liquid whose viscosity index has to be found. Take H from the table.

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

$$H = 0{,}168\ 4\ Y^2 + 11{,}85\ Y - 97 \qquad ...(7)$$

5.1.3 Examples of calculation :

1) Measured kinematic viscosity at 40 °C of the petroleum product whose viscosity index is to be calculated = 22,83 mm²/s; kinematic viscosity at 100 °C of the petroleum product whose viscosity index is to be calculated = 5,05 mm²/s.

From the table (by interpolation) $H = 28{,}97$

Substituting in equation (6) (by logarithms) :

$$N = \frac{\log 28{,}97 - \log 22{,}83}{\log 5{,}05} = 0{,}147\ 08$$

Substituting in equation (5) and rounding to the nearest whole number :

$$VI = \frac{(\text{antilog } 0{,}147\ 08) - 1}{0{,}007\ 15} + 100$$

$$= \frac{1{,}403\ 07 - 1}{0{,}007\ 15} + 100 = 156{,}37$$

VI = 156

2) Measured kinematic viscosity at 40 °C of the petroleum product whose viscosity index is to be calculated = 53,47 mm²/s; kinematic viscosity at 100 °C of the petroleum product whose viscosity index is to be calculated = 7,80 mm²/s.

From the table, $H = 57{,}31$

Substituting in equation (6) (by logarithms) :

$$N = \frac{\log 57{,}31 - \log 53{,}47}{\log 7{,}80} = 0{,}033\ 76$$

Substituting in equation (5) and rounding to the nearest whole number :

$$VI = \frac{(\text{antilog } 0{,}033\ 76) - 1}{0{,}007\ 15} + 100$$

$$= \frac{1{,}080\ 84 - 1}{0{,}007\ 15} + 100 = 111{,}31$$

VI = 111

NOTE — When the number is exactly halfway between the nearest two whole numbers, round it to the nearest whole number. For example, 115,5 should be reported as 116.

5.2 Expression of results

Express the results as the viscosity index, VI, to the nearest whole number.

5.3 Precision

The precision of a viscosity index value depends on the precision of the two independent kinematic viscosity values from which it is derived. The results of two viscosity index calculations shall be considered suspect if the values of the kinematic viscosities differ by more than the amounts quoted for repeatability or reproducibility as given in ISO 3104. The precision levels given in the following table are based entirely on the precision levels given in ISO 3104.

Kinematic viscosity at 100 °C mm²/s	Precision			
	VI = 100		VI = 200	
	Repeatability	Reproducibility	Repeatability	Reproducibility
4	1,4	2,8	2,2	4,4
6	1,1	2,2	1,7	3,5
8	1,0	2,0	1,5	3,0
15	0,7	1,5	1,1	2,3
30	0,6	1,2	0,9	1,8
50	0,5	1,0	0,8	1,6

The precision number for any kinematic viscosity or VI value may be calculated with sufficient accuracy by performing linear interpolations.

The repeatabilities and reproducibilities given are for a probability level of 95 %.

5.4 Test report

The test report shall contain the information as detailed in 4.4.