Designation: D2270 – 10 (Reapproved 2016)

British Standard 4459

Designation: 226/91 (95)

Standard Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C 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 U.S. 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 °C and 100 °C.

NOTE 1—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.

1.2 This practice does not apply to petroleum products with kinematic viscosities less than 2.0 mm^2/s at 100 °C. Table 1 given in this practice applies to petroleum products with kinematic viscosities between 2 mm^2/s 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.

1.2.1 In cases where kinematic viscosity data are not available at temperatures of 40 °C and 100 °C, an estimate may be made of the viscosity index by calculating the kinematic viscosity at temperatures of 40 °C 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 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, D7042, IP 71, or ISO 3104.

1.3.1 If Viscosity Index calculated for a given sample using kinematic viscosity measurements from different test methods are in disagreement, the values calculated from Test Method D445 measurements shall be accepted.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4.1 The values stated in SI units are to be regarded as the standard. For user reference, 1 $mm^2/s = 10^{-6} m^2/s$ = 1 cSt.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D341 Practice 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

D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *ISO Standards:*[4]

ISO 3104 Petroleum Products—Transparent and Opaque Liquids—Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity

[1] This practice is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, 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 Jan. 1, 2016. Published February 2016. Originally approved in 1964. Last previous edition approved in 2010 as D2270 – $10^{\varepsilon 1}$. DOI: 10.1520/D2270-10R16.

[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 RR: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, http://www.ansi.org.

2.3 *Energy Institute Standard:*[5]
IP 71 Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity

3. Terminology

3.1 *Definitions:*

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 °C 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.

4.4 Viscosity Index is sometimes used to characterize base oils for purposes of establishing engine testing requirements for engine oil performance categories.[6]

5. Procedure

5.1 Determine the kinematic viscosity of the sample at 40 °C and 100 °C in accordance with Test Method D445, Test Method D7042, ISO 3104, or IP 71.

5.2 *Calculation:*

5.2.1 If the kinematic viscosity of the sample at 100 °C is less than or equal to 70 mm^2/s, 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 shall not be reported for oils with kinematic viscosity of less than 2.0 mm^2/s at 100 °C.

5.2.2 If the kinematic viscosity is greater than 70 mm^2/s at 100 °C, calculate the values of L and H as follows:

$$L = 0.8353\,Y^2 + 14.67\,Y - 216 \quad (1)$$

$$H = 0.1684\,Y^2 + 11.85\,Y - 97 \quad (2)$$

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, mm^2/s,
Y = kinematic viscosity at 100 °C of the oil whose viscosity index is to be calculated, mm^2/s, 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, mm^2/s.

5.2.3 If $U > H$, calculate the viscosity index, VI, of the oil as follows:

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

where:

U = kinematic viscosity at 40 °C of the oil whose viscosity index is to be calculated, mm^2/s.

5.2.3.1 *Calculation Example*—Measured kinematic viscosity at 40 °C of the oil whose viscosity index is to be calculated = 73.30 mm^2/s; kinematic viscosity at 100 °C of the oil whose viscosity index is to be calculated = 8.86 mm^2/s.

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:

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

$$VI = 92 \quad (5)$$

5.2.4 If $U < H$, calculate the viscosity index, VI , of the oil as follows:

$$VI = [((\mathit{anti}\log N) - 1)/0.00715] + 100 \quad (6)$$

where:

$$N = (\log H - \log U)/\log Y \quad (7)$$

or

$$Y^N = H/U \quad (8)$$

5.2.4.1 *Calculation Example*—Measured kinematic viscosity at 40 °C of the oil whose viscosity index is to be calculated = 22.83 mm^2/s; kinematic viscosity at 100 °C of the oil whose viscosity index is to be calculated = 5.05 mm^2/s:

From Table 1 (by interpolation) H = 28.975

Substituting by Eq 7 (by logarithms):

$$N = \left[\frac{\log(28.975) - \log(22.83)}{\log(5.05)}\right] = 0.14719 \quad (9)$$

Substituting in Eq 6 and rounding to the nearest whole number:

$$VI = \left[\frac{\mathit{anti}\log(0.14719) - 1}{0.00715}\right] + 100 = \left[\frac{1.40343 - 1}{0.00715}\right] + 100$$

$$= \left[\frac{0.40343}{0.00715}\right] + 100 = 156.4235 \quad (10)$$

$$VI = 156$$

5.2.4.2 *Calculation Example*—Measured kinematic viscosity at 40 °C of the oil whose viscosity index is to be calculated = 53.47 mm^2/s; kinematic viscosity at 100 °C of the oil whose viscosity index is to be calculated = 7.80 mm^2/s:

From Table 1, H = 57.31

Substituting in Eq 7 (by logarithms):

[5] Available from Energy Institute, 61 New Cavendish St., London, W1G 7AR, U.K., http://www.energyinst.org.

[6] API 1509, "*Engine Oil Licensing and Certification System*, " 16e, American Petroleum Institute, April 2007.