Designation: D2501 – 91 (Reapproved 2005)

Standard Test Method for Calculation of Viscosity-Gravity Constant (VGC) of Petroleum Oils[1]

This standard is issued under the fixed designation D2501; 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.

1. Scope

1.1 This test method covers the calculation of the viscosity-gravity constant (VGC) of petroleum oils[2] having viscosities in excess of 4 cSt. = 4×10^{-6} m^{-2}/s at 40°C (104°F).

1.2 Annex A1 describes a method for calculating the VGC from Saybolt (SUS) viscosity and relative density.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.4 *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]

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

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

D1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D2140 Practice for Calculating Carbon-Type Composition of Insulating Oils of Petroleum Origin

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

3. Summary of Test Method

3.1 The kinematic viscosity at 40°C (104°F) and the density at 15°C of the oil are determined. If the oil is extremely viscous, or if it is otherwise inconvenient to determine the viscosity at 40°C, the kinematic viscosity at 100°C (212°F) can be used. The viscosity-gravity constant is calculated from the measured physical properties using the appropriate equation.

4. Significance and Use

4.1 The viscosity-gravity constant (VGC) is a useful function for the approximate characterization of the viscous fractions of petroleum.[2] It is relatively insensitive to molecular weight and is related to a fluids composition as expressed in terms of certain structural elements. Values of VGC near 0.800 indicate samples of paraffinic character, while values close to 1.00 indicate a preponderance of aromatic structures. Like other indicators of hydrocarbon composition, the VGC should not be indiscriminately applied to residual oils, asphaltic materials, or samples containing appreciable quantities of nonhydrocarbons.

5. Measurement of Physical Properties

5.1 Preferably, determine the kinematic viscosity at 40°C as described in Test Method D445. However, if the sample is extremely viscous or if it is otherwise inconvenient to measure the viscosity at 40°C, the viscosity at 100°C may be determined.

5.2 Determine the density at 15°C in accordance with Test Method D1298 or Test Method D4052. Equivalent results can be obtained by determining API Gravity at 60°F (15.56°C) in accordance with Test Method D287, and converting the result to density at 15°C by means of Table 3 of the Petroleum Measurement Tables (American Edition).[4]

NOTE 1—If it is necessary to convert a result obtained using the digital

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[2] Coats, H. B., and Hill, J. B., *Industrial and Engineering Chemistry*, Vol 20, 1928, p. 641.

[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] Published jointly by, and available from, ASTM Headquarters and Energy Institute, 61 New Cavendish St., London W1M 8AP. Companion volumes—the British Edition and the Metric Edition—are also available. These tables supersede all other similar tables previously published by either of these societies and the National Bureau of Standards Circular C-410 and the supplement to Circular C-410.

density meter to a density at another temperature, the Petroleum Measurement Tables can be used only if the glass expansion factor has been excluded.

6. Calculation of Viscosity-Gravity Constant

6.1 *From Kinematic Viscosity at 40°C and Density at 15°C*—Use the following equation to calculate the VGC from the measured properties:

$$VGC = \frac{G - 0.0664 - 0.1154\,Log(V - 5.5)}{0.94 - 0.109\,Log(V - 5.5)} \quad (1)$$

where:
G = density at 15°C, g/mL, and
V = kinematic viscosity at 40°C, cSt.

6.2 *From Kinematic Viscosity at 100°C and Density at 15°C*—Use the following equation to calculate the VGC:

$$VGC = \frac{G - 0.108 - 0.1255\,Log(V' - 0.8)}{0.90 - 0.097\,Log(V' - 0.8)} \quad (2)$$

where:
G = density at 15°C, g/mL, and
V' = kinematic viscosity at 100°C, cSt.

7. Report

7.1 Report the calculated VGC to the nearest .002 unit.

7.2 If the viscosity at 100°C was used for the calculation, state this in the report.

8. Precision and Bias

8.1 The calculation of viscosity-gravity constant from kinematic viscosity at 40°C and density at 15°C is exact. Precision limits are not assigned to this calculation.

8.2 The precision of the calculated VGC is dependent only on the precision of the original determinations of viscosity and density. Those precision statements are found in their respective test methods. The precision can be calculated as follows:

8.2.1 For viscosity measured at 40°C,

$$r_Y = \frac{1}{0.94 - 0.109\log_{10}(V - 5.5)} \cdot \sqrt{{r_G}^2 + {r_V}^2 \frac{0.00224\,(Y - 1.059)^2}{(V - 5.5)^2}} \quad (3)$$

where:
r_Y = precision of the VGC,
r_G = precision of the gravity from D287,
r_V = precision of the viscosity from D445,
V = measured viscosity, and
Y = VGC.

8.2.2 For viscosity measured at 100°C,

$$r_Y = \frac{1}{0.90 - 0.097\ \log_{10}(V - 0.8)} \cdot \sqrt{{r_G}^2 + {r_V}^2 \frac{0.00177(Y - 1.294)^2}{(V - 0.8)^2}} \quad (4)$$

8.3 The VGC calculated from the viscosity at 100°C can differ slightly from that calculated from the viscosity at 40°C. A statistical evaluation of VGC data derived from equivalent viscosities at both 100°F and 210°F suggests that in the range from about 0.80 to 0.95 VGC, the expected average difference will be approximately 0.003 units. Whenever possible, it is preferable to determine the VGC using Eq 1.

8.4 *Bias*—The procedure in Test Method D2501 for calculation of viscosity-gravity constant has no bias because the value of viscosity-gravity constant can be defined only in terms of a test method.

8.5 The term viscosity-gravity constant is also used in Test Method D2140, for determining carbon-type composition of insulating oils of petroleum origin. The equations used are different from those in this test method; the bias between the two test methods is unknown.

9. Keywords

9.1 aromatic; density; kinematic viscosity; paraffinic

ANNEX

(Mandatory Information)

A1. CALCULATION OF VISCOSITY-GRAVITY CONSTANT FROM SAYBOLT VISCOSITY AND RELATIVE DENSITY (SPECIFIC GRAVITY)

A1.1 The calculation of viscosity-gravity constant (VGC) can also be calculated from viscosity in units of Saybolt seconds universal (SUS) and relative density (specific gravity).

A1.2 *From Saybolt Viscosity at 100°F and Relative Density (Specific Gravity) 60/60°F*—Use the following equation to calculate the VGC from the measured properties:

$$VGC = \frac{10G - 1.0752\log(V - 38)}{10 - \log(V - 38)} \quad (A1.1)$$

where:
G = relative density (specific gravity) at 60/60°F, and
V = Saybolt Universal viscosity at 100°F.

A1.3 *From Saybolt Viscosity at 210°F and Relative Density (Specific Gravity) 60/60°F*—Use the following equation to calculate the VGC:

$$VGC = \frac{G - 0.1244 \log(V_1 - 31)}{0.9255 - 0.0979 \log (V_1 - 31)} - 0.0839 \qquad \text{(A1.2)}$$

where:

G = relative density (specific gravity) at 60/60°F, and
V_1 = Saybolt Universal viscosity at 210°F.

A1.4 The viscosity-gravity constant calculated from the Saybolt viscosity at 210°F can differ slightly from that calculated from the 100°F viscosity. A statistical evaluation of VGC data derived from both the 100°F and 210°F viscosities suggests that in the range from about 0.80 to 0.5 VGC, the expected average difference will be approximately 0.003 units. Whenever possible, it is preferable to determine the VGC using Eq A1.1.