INTERNATIONAL

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Standard Practice for Calculating Viscosity of a Blend of Petroleum Products[1]

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1. Scope*

1.1 This practice covers the procedures for calculating the estimated kinematic viscosity of a blend of two or more petroleum products, such as lubricating oil base stocks, fuel components, residual fuel oil with kerosene, crude oils, and related products, from their kinematic viscosities and blend fractions.

1.2 This practice allows for the estimation of the fraction of each of two petroleum products needed to prepare a blend meeting a specific viscosity.

1.3 This practice may not be applicable to other types of products, or to materials which exhibit strong non-Newtonian properties, such as viscosity index improvers, additive packages, and products containing particulates.

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

1.5 Logarithms may be either common logarithms or natural logarithms, as long as the same are used consistently. This practice uses common logarithms. If natural logarithms are used, the inverse function, exp(×), must be used in place of the base 10 exponential function, $10^{\times}$, used herein.

1.6 *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, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D341 Practice for Viscosity-Temperature Equations and Charts for Liquid Petroleum or Hydrocarbon Products

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

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

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

2.2 *ASTM Adjuncts:*

Calculating the Viscosity of a Blend of Petroleum Products Excel Worksheet[3]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminology D4175.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ASTM Blending Method, n*—a blending method at constant temperature, using components in volume percent.

3.2.2 *blend fraction, n*—the ratio of the amount of a component to the total amount of the blend. Blend fraction may be expressed as mass percent or volume percent.

3.2.3 *blending method, n*—an equation for calculating the viscosity of a blend of components from the known viscosities of the components.

3.2.4 *dumbbell blend, n*—a blend made from components of widely differing viscosity.

3.2.4.1 *Example*—a blend of S100N and Bright Stock.

3.2.5 *inverse blending method, n*—an equation for calculating the predicted blending fractions of components to achieve a blend of given 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.

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[2] 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.

[3] Available from ASTM International Headquarters. Order Adjunct No. ADJD7152-EA. Original adjunct produced in 2006.

***A Summary of Changes section appears at the end of this standard**

3.2.6 *mass blend fraction, n*—The ratio of the mass of a component to the total mass of the blend.

3.2.7 *McCoull-Walther-Wright Function, n*—a mathematical transformation of viscosity, generally equal to the logarithm of the logarithm of kinematic viscosity plus a constant, log[log(v+0.7)]. For viscosities below 2 mm^2/s, additional terms are added to improve accuracy.

3.2.8 *modified ASTM Blending Method, n*—a blending method at constant temperature, using components in mass percent.

3.2.9 *modified Wright Blending Method, n*—a blending method at constant viscosity, using components in mass percent.

3.2.10 *volume blend fraction, n*—The ratio of the volume of a component to the total volume of the blend.

3.2.11 *Wright Blending Method, n*—a blending method at constant viscosity, using components in volume percent.

3.3 *Symbols:*

f_{ij} = blending fraction of component i calculated at temperature t_j. Blending fraction may be in mass percent or volume percent.

m_i = slope of the viscosity-temperature line,

$$\frac{(W_{i1} - W_{i0})}{(T_{i1} - T_{i0})}$$

m_i^{-1} = reciprocal of the viscosity-temperature slope, m_i

t_B = temperature, in Celsius, at which the blend has viscosity v_B

t_{ij} = temperature, in Celsius, at which component i has viscosity v_{ij}

T_{ij} = transformed temperature

$$T_{ij} = log(273.15 + t_{ij}) \quad (1)$$

v_B = predicted kinematic viscosity of the blend, in mm^2/s, at temperature t_B if component blend fractions are known, or desired viscosity of the blend if component blend fractions are being calculated

v_{ij} = viscosity of component i at temperature t_j

W_{ij} = MacCoull-Walther-Wright function, a transformation of viscosity:

$$W_{ij} = \log[\log(v_{ij} + 0.7 + \exp(-1.47 - 1.84v_{ij} - 0.51v_{ij}^2))] \quad (2)$$

where log is the common logarithm (base 10) and exp(x) is e (2.716...) raised to the power x.

W_H = arbitrary high reference viscosity, transformed using Eq 2

W_L = arbitrary low reference viscosity, transformed using Eq 2

4. Summary of Practice

4.1 The Wright Blending Method calculates the viscosity of a blend of components at a given temperature from the known viscosities, temperatures, and blending fractions of the components. The viscosities and temperatures of the components and the blend are mathematically transformed into MacCoull-Walther-Wright functions. The temperatures at which each component has two reference viscosities are calculated. The transformed reference temperatures are summed over all components as a weighted average, with the blend fractions as the weighting factors. The two temperatures at which the blend has the reference viscosities are used to calculate the blend viscosity at any other temperature.

4.2 The Inverse Wright Blending Method calculates the blend fractions of components required to meet a target blend viscosity from the known viscosities and temperatures of the components. The viscosities and temperatures of the components and the blend are mathematically transformed into MacCoull-Walther-Wright functions. The temperatures at which each component has the target blend viscosity are calculated. The component transformed temperatures are summed over all components, as a weighted average, to meet the target blend transformed temperature. The weighting factors are the desired blend fractions, which are obtained by inverting the weighted summation equation.

4.3 The ASTM Blending Method calculates the viscosity of a blend of components at a given temperature from the known viscosities of the components at the same temperature and their blending fractions. The viscosities of the components and the blend are mathematically transformed into MacCoull-Walther-Wright functions. The transformed viscosities are summed over all components as a weighted average, with the blend fractions as the weighting factors. The transformed viscosity is untransformed into viscosity units.

4.4 The Inverse ASTM Blending Method calculates the blend fractions of components required to meet a target blend viscosity at a given temperature from the known viscosities of the components at the same temperature. The viscosities of the components and the blend are mathematically transformed into MacCoull-Walther-Wright functions. The component transformed viscosities are summed over all components, as a weighted average, to equal the target blend transformed viscosity. The weighting factors are the desired blend fractions, which are obtained by inverting the weighted summation equation.

5. Significance and Use

5.1 Predicting the viscosity of a blend of components is a common problem. Both the Wright Blending Method and the ASTM Blending Method, described in this practice, may be used to solve this problem.

5.2 The inverse problem, predicating the required blend fractions of components to meet a specified viscosity at a given temperature may also be solved using either the Inverse Wright Blending Method or the Inverse ASTM Blending Method.

5.3 The Wright Blending Methods are generally preferred since they have a firmer basis in theory, and are more accurate. The Wright Blending Methods require component viscosities to be known at two temperatures. The ASTM Blending Methods are mathematically simpler and may be used when viscosities are known at a single temperature.