



Designation: D6022 – 19

Standard Practice for Calculation of Permanent Shear Stability Index¹

This standard is issued under the fixed designation D6022; 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 practice specifies the procedure for the calculation of Permanent Shear Stability Index (PSSI) of an additive using viscosities before and after a shearing procedure.

1.2 PSSI is calculated for a single blend component and can then be used to estimate the effects of that component on finished lubricant blends.

1.3 This practice is applicable to many products and may use data from many different test methods. The calculation is presented in its most general form in order not to restrict its use.

1.4 *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

- D2603 Test Method for Sonic Shear Stability of Polymer-Containing Oils
- D4485 Specification for Performance of Active API Service Category Engine Oils
- D5275 Test Method for Fuel Injector Shear Stability Test (FISST) for Polymer Containing Fluids
- D5621 Test Method for Sonic Shear Stability of Hydraulic Fluids
- D6278 Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus
- D6709 Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)

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.

Current edition approved Dec. 1, 2019. Published January 2020. Originally approved in 1996. Last previous edition approved in 2012 as D6022 – 06 (2012). DOI: 10.1520/D6022-19.

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.

D7109 Test Method for Shear Stability of Polymer-Containing Fluids Using a European Diesel Injector Apparatus at 30 Cycles and 90 Cycles

2.2 CEC Standards:³

- CEC L-14-93 Evaluation of the Mechanical Shear Stability of Lubricating Oils Containing Polymers
- CEC L-45-99 Viscosity Shear Stability of Transmission Lubricants (KRL)

3. Terminology

3.1 Definitions:

3.1.1 *degree of thickening (DT), n*—the ratio of an oil's viscosity with an additive to that oil's viscosity without the additive. A measure of the amount by which an additive increases the base fluid viscosity.

3.1.2 *permanent shear stability index (PSSI), n*—a measure of the irreversible decrease, resulting from shear, in an oil's viscosity contributed by an additive.

3.1.2.1 *Discussion*—PSSI is a property calculated for a single component. Viscosity Loss (*q.v.*) is a property measured for a finished oil.

3.1.3 *shear, adj*—a relative movement of molecules or molecular aggregates that occurs in flowing liquids. A shear flow is one in which the spatial velocity gradient is perpendicular to the direction of flow.

3.1.3.1 *Discussion*—Not all flow geometries meet this definition.

3.1.4 *shear, v*—to subject a liquid to a shear flow.

3.1.4.1 *Discussion*—Shearing an oil can sometimes cause scission of certain molecular species, resulting in a decrease in viscosity. Not all oils exhibit this response. Common ways of shearing oils to elicit this effect include injection through a small orifice and flow through gears or bearings. Irradiation with sonic energy can also decrease the viscosity of some oils.

3.1.5 *Viscosity Loss (VL), n*—a measure of the decrease in an oil's viscosity.

3.1.5.1 *Discussion*—Viscosity Loss is a property measured for a finished oil. Permanent Shear Stability Index (*q.v.*) is a property calculated for a single component. Some test methods report VL as a relative change, which is dimensionless (for

³ Available from Organization for Economic Cooperation and Development, Madou Plaza, Place Madou 1, B-1030 Brussels, Belgium.

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

example, Test Methods **D2603**, **D5275**, **D6278**, and **D7109**). Some test methods and specifications report VL as an absolute change, which has the same dimensions as the viscosity measurements (for example, Specification **D4485** and Test Method **D5621** and **D6709**).

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *base fluid, n*—an oil without the additive whose PSSI is to be determined. The base fluid shall have a viscosity loss of zero, within the precision of the shearing test used.

3.2.1.1 *Discussion*—A base fluid could be a mineral oil, a synthetic oil, a formulation containing additives, or other system meeting the requirement of zero viscosity loss.

3.2.2 *sheared oil, n*—the test oil, after shearing.

3.2.3 *test oil, n*—base fluid with the additive whose PSSI is to be determined.

3.2.4 *unsheared oil, n*—the test oil, prior to shearing.

4. Summary of Practice

4.1 An index is calculated representing the change, due to shearing, in an additive's contribution to a lubricant's viscosity. A low index represents high resistance to permanent change.

4.2 Oils can be sheared by many means, including bench tests designed for that purpose, engine tests, and field service. A PSSI can be calculated for each. These indices can be used to compare the shearing severity of each test.

NOTE 1—Some methods, especially engine tests and field service, may include conditions where other effects (for example, evaporative loss, oxidation, fuel dilution, soot accumulation, and so forth.) contribute to viscosity changes. The PSSI calculated from these types of service may not be representative of pure shearing.

4.2.1 ASTM tests commonly used to shear oils include Test Methods **D2603**, **D5275**, **D5621**, **D6278**, and **D7109**, among others.

4.2.2 Other standards organizations publish test methods which may be suitable for shearing oils.⁴

5. Significance and Use

5.1 Permanent Shear Stability Index (PSSI) is a measure of the loss of viscosity, due to shearing, contributed by a specified additive.

NOTE 2—For example, a PSSI of 50 means the additive will lose 50 % of the viscosity it contributes to the finished oil.

5.2 The selection of appropriate base fluids and additive concentrations to be used in test oils is left to individual operators or companies. These choices will depend on the intended application for the additive.

NOTE 3—PSSI may depend more strongly on base fluid, additive concentration, additive chemistry, and the presence of other additives for base fluids of unusual composition (for example, esters) or if additives outside the common range of chemistries and concentrations are used. Caution should be exercised when interpreting results from different sources.

6. Procedure

6.1 Calculate the degree of thickening:

$$DT = V_0/V_b \quad (1)$$

where:

V_0 = viscosity of the unsheared oil, and
 V_b = viscosity of the base fluid.

6.1.1 Viscosities shall be measured using the same test method at the same conditions of temperature and shear rate or shear stress and reported in the same units.

6.2 If the degree of thickening is less than **1.2**, PSSI cannot be determined from these data.

NOTE 4—Once PSSI has been determined for an additive, calculations using that PSSI can be made for oil blends where the degree of thickening is less than **1.2**.

6.3 If the degree of thickening is greater than or equal to **1.2**, calculate PSSI using the equation:

$$PSSI = 100 \times (V_0 - V_s)/(V_0 - V_b) \quad (2)$$

where:

PSSI = Permanent Shear Stability Index,
 V_0 = viscosity of the unsheared oil,
 V_s = viscosity of the sheared oil, and
 V_b = viscosity of the base fluid.

6.3.1 Viscosities shall be measured using the same test method at the same conditions of temperature and shear rate or shear stress and reported in the same units.

NOTE 5—If V_b is close in value to V_0 , that is if the degree of thickening is small, the denominator in Eq 2 approaches zero, and the precision of PSSI becomes unacceptable. A minimum degree of thickening of **1.2** was chosen to avoid meaningless calculations of PSSI.

6.3.2 For example, an additive is added to a base fluid of kinematic viscosity 10 mm²/s at 100 °C, resulting in an un-sheared oil kinematic viscosity of 15 mm²/s at 100 °C. After a shearing test, the sheared oil has a viscosity of 13 mm²/s at 100 °C. The PSSI of the additive is calculated as:

$$DT = 15/10 = 1.5 > 1.2 \quad (3)$$

$$PSSI = 100 \times (15 - 13)/(15 - 10) = 100 \times (2/5) = 40 \quad (4)$$

6.4 Re-arranging Eq 2 gives other useful relationships. The viscosity of a formulation, after shearing, could be estimated as:

$$V_s = V_0 - (PSSI/100) \times (V_0 - V_b) \quad (5)$$

or

$$V_s = V_0 (1 - PSSI/100) + V_b \times (PSSI/100) \quad (6)$$

and the viscosity of the un-sheared oil is:

$$V_0 = [V_s - V_b \times (PSSI/100)]/[1 - (PSSI/100)] \quad (7)$$

6.4.1 For example, using an additive with a PSSI of 50 and a base oil of kinematic viscosity 8 mm²/s, it is desired to have a sheared oil of no less than 12 mm²/s. To what kinematic viscosity should the un-sheared oil be blended?

$$V_0 = [V_s - V_b \times (PSSI/100)]/[1 - (PSSI/100)] \quad (8)$$

$$= [12(8)(0.5)]/[1 - 0.5] = 16$$

⁴ CEC L-14-93 and CEC L-45-99, for example.