



Standard Test Method for Measuring Apparent Viscosity at High-Temperature and High-Shear Rate by Multicell Capillary Viscometer¹

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INTRODUCTION

Several different configurations of capillary viscometers have been successfully used for measuring the viscosity of engine oils at the high shear rates and high temperatures that occur in engines. See Test Method D 4624. This test method covers the use of a single apparatus² at a single temperature and single shear rate to achieve greater uniformity and improved precision.

1. Scope

1.1 This test method covers the laboratory determination of high-temperature high-shear (HTHS) viscosity of engine oils at a temperature of 150°C using a multicell capillary viscometer containing pressure, temperature, and timing instrumentation. The shear rate for this test method corresponds to an apparent shear rate at the wall of $1.4 \times 10^6 \text{ s}^{-1}$.³ This shear rate has been found to decrease the discrepancy between this test method and other high-temperature high-shear test methods³ used for engine oil specifications. Viscosities are determined directly from calibrations that have been established with Newtonian oils with viscosities from 2 to 5 mPa·s at 150°C.

1.2 *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:

D 4624 Test Method for Measuring Apparent Viscosity by Capillary Viscometer at High Shear Rate and High Temperature⁴

D 4683 Test Method for Measuring Viscosity at High Shear

Rate and High Temperature by Tapered Bearing Simulator⁵

D 4741 Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered Plug Viscometer⁵

3. Terminology

3.1 Definitions:

3.1.1 *apparent shear rate at the wall*—shear rate at the wall of the capillary calculated for a Newtonian fluid, as follows:

$$S_a = 4V/\pi R^3 t \quad (1)$$

where:

S_a = apparent shear rate at the wall, s^{-1} ,

V = volume, mm^3 ,

R = capillary radius, mm, and

t = measured flow time, s.

3.1.1.1 *Discussion*—The actual shear rate at the wall will differ for a non-Newtonian fluid.

3.1.2 *apparent viscosity*—the determined viscosity obtained by this test method.

3.1.3 *density*—mass per unit volume.

3.1.3.1 *Discussion*—In the SI, the unit of density is the kilogram per metre cubed (kg/m^3); the gram per cubic centimetre (g/cm^3) is often used. One kg/m^3 is 10^{-3} g/cm^3 .

3.1.4 *kinematic viscosity*—the ratio of the viscosity to the density of the fluid.

3.1.4.1 *Discussion*—Kinematic viscosity is a measure of a fluid's resistance to flow under the force of gravity. In the SI, the unit of kinematic viscosity is the metre squared per second (m^2/s); for practical use, a submultiple (millimetre squared per second, mm^2/s) is more convenient. The centistoke (cSt) is $1 \text{ mm}^2/\text{s}$ and is often used.

3.1.5 *Newtonian oil or fluid*—an oil or fluid that exhibits a constant viscosity at all shear rates or shear stresses.

¹ This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.07.0B on High Temperature Rheology of Non-Newtonian Fluids.

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² Manning, R. E., and Lloyd, W. A., "Multicell High Temperature High-Shear Capillary Viscometer," SAE Paper 861562. Available from Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096.

³ Girshick, F., "Non-Newtonian Fluid Dynamics in High Temperature High Shear Capillary Viscometers," SAE Paper 922288. Available from Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096.

⁴ *Annual Book of ASTM Standards*, Vol 05.02.

⁵ *Annual Book of ASTM Standards*, Vol 05.03.