



Standard Test Method for Measuring Apparent Viscosity by Capillary Viscometer at High-Temperature and High-Shear Rates¹

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This standard has been approved for use by agencies of the Department of Defense.

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. This test method evolved from a cooperative program that included a wide variety of viscometer designs and procedures. Therefore, this test method is very general but its precision has not been established for any viscometer designs or procedures not evaluated in the cooperative program.

1. Scope

1.1 This test method covers the measurement of high-temperature high-shear viscosity at 150°C. The shear rate for this test method corresponds to an apparent shear rate at the wall of 10^6 s^{-1} . This is the shear rate at the wall calculated for a Newtonian oil. For non-Newtonian oils, the actual shear rate at the wall will vary from this value.

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 1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer²

D 4683 Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered Bearing Simulator³

D 4741 Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered Plug Viscometer³

3. Terminology

3.1 Definitions:

3.1.1 *viscosity*—the ratio between shear stress and shear rate at the same location. It is sometimes called the coefficient of

viscosity, or the dynamic viscosity. It is a measure of a fluid's resistance to flow. In the SI, the unit of viscosity is a pascal second (Pa·s); for practical use a submultiple (millipascal second, mPa·s) is more convenient. The centipoise (cP) is 1 mPa·s and is often used.

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

3.1.3 *kinematic viscosity*—the ratio of the viscosity to the density of the fluid. It 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 mm^2/s and is often used.

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

3.1.5 *non-Newtonian oil or fluid*—an oil or fluid that exhibits a viscosity that varies with changing shear rate or shear stress.

3.1.6 *shear rate*—the spatial gradient of velocity in laminar flow; the derivative of velocity with respect to distance in a direction perpendicular to the direction of flow. The derived unit of shear rate is velocity divided by length. With time in seconds and with consistent units of length, shear rate becomes reciprocal seconds, or s^{-1} . In a capillary, the significant shear rate for a Newtonian fluid is as follows:

$$S = 4Q/\pi R^3 \quad (1)$$

where:

S = shear rate, s^{-1} ,

Q = flow rate, and

R = capillary radius in consistent units.

3.1.7 *shear stress*—force per area of fluid in the direction of flow. In a capillary viscometer, the significant shear stress is the maximum shear stress at the wall, that is, the total force acting

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² *Annual Book of ASTM Standards*, Vol 05.01.

³ *Annual Book of ASTM Standards*, Vol 05.03.