Designation: D 3205 – 86 (Reapproved 1991)

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Viscosity of Asphalt with Cone and Plate Viscometer[1]

This standard is issued under the fixed designation D 3205; 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 determination of the viscosity of asphalt cements by means of a cone-plate viscometer. It is applicable to materials having viscosities in the range from 10^3 to 10^{10} P (10^2 to 10^9 Pa·s) and is therefore suitable for use at temperatures where viscosity is in the range indicated. The shear rate may vary between approximately 10^{-3} to 10^2 s^{-1} and the method is suitable for determination on materials having either Newtonian or non-Newtonian flow properties.

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:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup[3]

D 93 Test Method for Flash Point by Pensky-Martens Closed Cup Tester[3]

E 1 Specification for ASTM Thermometers[4]

3. Definitions

3.1 *viscosity*—the resistance to deformation or internal friction of a liquid, expressed as the ratio of shear stress to shear rate, whether this ratio is constant or not. The unit of viscosity obtained by dividing the shearing stress in dynes/square centimetre by the rate of shear in reciprocal seconds is called the poise. The SI unit of viscosity has the dimensions of pascal-seconds (Pa·s), and is equivalent to 10 P.

3.2 *Newtonian liquid*—a liquid in which the rate of shear is proportional to the shearing stress.

3.3 *non-Newtonian liquid*—a liquid in which the rate of shear is not proportional to the shearing stress.

4. Summary of Method

4.1 The sample is placed between the cone-and-plate assembly which is then brought to the test temperature. Weights acting through a pulley apply torque to the cone and the angular velocity of the cone is measured. Viscosity in poises and shear rate in reciprocal seconds are calculated from the angular velocity, torque, and calibration constants.

4.2 Some asphalt cements may fracture at shear stresses within the range of this instrument. This fracture stress may be reported.

5. Significance and Use

5.1 The rheological properties of asphalt cements are used for specification purposes for road pavement construction. The instrument provides measurements over a wide range of temperatures for use in research and development of asphalt cements and other bituminous materials.

6. Apparatus

6.1 *Cone-Plate Viscometer,*[5,6] as shown in Fig. 1 with metric weights from 10 to 20 000 g. It is used for measuring the viscosities in the range from 10^3 to 10^{10} P (10^2 to 10^9 Pa·s) at shear rates from 10^{-3} to 10^{-2} s^{-1}. Important dimensions of each cone and approximate constants are given in Table 1. The approximate data of Table 2 may be helpful in the selection of the proper cone and load.

6.2 *Thermometers*—Calibrated mercury-in-glass thermometers of suitable range and graduated to 0.1°F (0.05°C). They shall conform to the requirements of Specification E 1. Calibrated ASTM kinematic viscosity thermometers are satisfactory. Other thermometric devices are permissible provided their accuracy, precision, and sensitivity are equal or better than ASTM kinematic viscosity thermometers.

6.3 *Bath*—A water, alcohol, or ethylene glycol bath suitable for the immersion of the plate and cone and of such height that the cone is immersed to a depth of at least 60 mm. The efficiency of the stirring and balance between heat losses and heat input must be such that the temperature of the water does not vary by more than ± 0.1°F (0.05°C).

6.4 *Timer*—A stop watch or other timer graduated in divisions of 0.1 s or less and accurate to within 0.01 % when tested

[1] This test method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.44 on Rheological Tests.

Current edition approved Nov. 28, 1986. Published January 1987. Originally published as D 3205 – 73 T. Last previous edition D 3205 – 79 (1985).

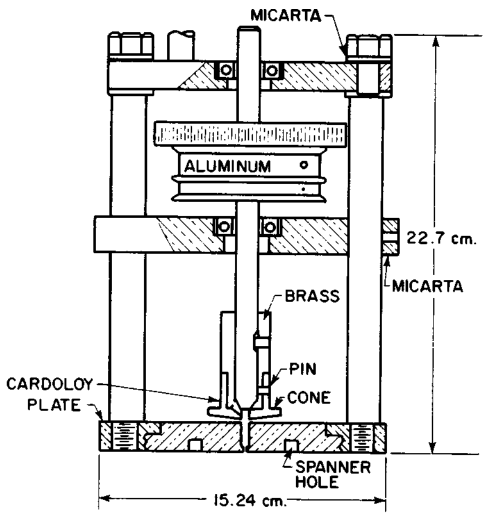
[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 05.01.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

[5] Sisko, A. W., “Determination and Treatment of Asphalt Viscosity Data” Highway Research Board, Highway Research Record No. 67, 1965.

[6] Manufactured by the Cannon Instrument Co., P.O. Box 16, State College, PA 16801.



NOTE: ALL PARTS STAINLESS EXCEPT AS INDICATED

FIG. 1 Assembly View of Viscometer

TABLE 1 Approximate Instrument Cone Sizes and Constants

Cone No.[A]	Approximate Cone Radius, cm[B]	Approximate Cone Angle, deg[C]	Approximate Cone Constant	
			K_D, deg^{-1}	K_S, dynes/cm^2·g
8	3.75	0.5	2.0	31 250
4	1.88	0.5	2.0	2000
2	0.94	0.5	2.0	

[A] Other cone sizes may be used.
[B] Exact cone and drum radii must be measured to determine K_S by calculation.
[C] Exact cone angle may be calculated from the determination of K_D by viscosity standards and measured cone and drum radii. K_D is the reciprocal of the angle between the cone and plate.

TABLE 2 Approximate Loads and Viscosities at Shear Rates of 1, 10^{-1}, and 10^{-2} s^{-1}

Cone No.	Load, g	Approximate Viscosities, MP, at Shear Rates of		
		1 s^{-1}	10^{-1} s^{-1}	10^{-2} s^{-1}
8	100	0.003	0.03	0.03
	1000	0.03	0.3	3
	10000	0.3	3	30
4	100	0.025	0.25	2.5
	1000	0.25	2.5	25
	10000	2.5	25	250
2	100	0.2	2	20
	1000	2	20	200
	10000	20	200	2000
Angular velocity, °/s		0.5	0.05	0.005

over intervals of not less than 15 min. Electrical timing devices may be used only on electrical circuits in which frequency is controlled to an accuracy of 0.05 % or better.

6.4.1 Alternating-current frequencies that are intermittently and not continuously controlled, as provided by some public power systems, can cause large errors, particularly over short timing intervals, when used to actuate electrical timing devices.

6.5 *Ohmmeter*, or any electrical device capable of indicating that contact between cone and plate is maintained prior to, and during the test.

7. Calibration

7.1 Determine the shear stress constant, K_S, the shear rate constant, K_D, and the friction correction F, as follows:

7.1.1 To calculate the shear stress constant, K_S, proceed as follows:

7.1.1.1 Using an accurate micrometer, measure the cone radius, r (diameter/2) to an accuracy of ±0.05 mm (±0.002 in.). The effective drum radius is the drum radius plus half the string thickness: measure the effective drum radius, R, to an accuracy of ±0.05 mm (±0.002 in.). Calculate K_S in dynes per (centimetre squared) gram as follows:

$$K_S = 3g\,R/2\pi r^3 \tag{1}$$

where:
r = radius of cone, cm,
R = effective radius of drum, cm, and
g = gravitational constant, 980 dynes/g.

7.1.2 Determine the shear rate constant, K_D, for each cone by direct calibration with viscosity standards (see Table 3 for available calibration standards). This is obtained by the following procedure:

7.1.2.1 Measure the angle of rotation, θ, in degrees, and the time, t, in seconds, at applied loads, L, from 5 to 500 g (the range of applied loads will depend on the size of the cone being calibrated).

7.1.2.2 Plot the angular velocity, θ/t, in degrees per second, as the ordinate versus the applied load, L, in grams, as the abscissa as shown in the example of Fig. 2. Determine the slope, m, of the line and calculate K_D in reciprocal degrees as follows:

$$K_D = K_S/\eta m \tag{2}$$

where:
K_S = has the value determined in Eq. 1,
η = viscosity of standard oil, P, and
m = slope of regression line resulting from plotting θ/t versus L.

7.1.3 Determine the friction correction, F, in grams by one of the following methods:

7.1.3.1 Use the equation:

$$F = L - (1/m)(\theta/t) \tag{3}$$

where:
F = friction correction, g,
L = applied load, g,
m = slope of the regression line,
θ = measured angle of rotation, deg, and
t = measured time of rotation, s.

Calculate the value of F for each load point and determine the average.

7.1.3.2 Determine the friction correction F from the plot of 7.1.2 as the intercept with the abscissa.

TABLE 3 Viscosity Standards

Viscosity Standard	Approximate Viscosity, *P*	
	At 68°F	At 86°F
N 30000[A]	1500	...
N 190000[A]	8000	...

[A] Available in 1-pt containers, price $40.00. F.O.B. State College, PA. Purchase orders should be addressed to Cannon Instrument Co., P.O. Box 16, State College, PA 16804.