Standard Method of Test for

Viscosity Determination of Asphalt Binder Using Rotational Viscometer

AASHTO Designation: T 316-13

AASHTO

1. SCOPE

1.1. This test method outlines the procedure for measuring the viscosity of asphalt binders at elevated temperature from 60 to over 200°C using a Rotational Viscometer apparatus as specified by M 320 and R 29.

1.2. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the application of regulatory limitations prior to use*.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 320, Performance-Graded Asphalt Binder
- R 29, Grading or Verifying the Performance Grade (PG) of an Asphalt Binder
- R 66, Sampling Asphalt Materials

2.2. *ASTM Standards*:

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers

3. TERMINOLOGY

3.1. *Definition*:

3.1.1. *viscosity*—the ratio between the applied shear stress and the rate of shear is called the coefficient of viscosity. This coefficient is a measure of the resistance to flow of the liquid. It is commonly called the viscosity. The SI unit of viscosity is the Pascal second (Pa·s).

4. SUMMARY OF METHOD

4.1. This test method can be used to measure the viscosity of asphalt at application temperatures. The torque required to maintain a constant rotational speed of a cylindrical spindle while submerged in an asphalt sample at a constant temperature is used to measure the relative resistance to rotation. The torque and speed are used to determine the viscosity of the binder in Pascal seconds.

5. SIGNIFICANCE AND USE

5.1. This test method can be used to measure the apparent viscosity of asphalt at application temperatures.

5.2. The measured viscosity at elevated temperatures can be used to determine whether the asphalt binder can be handled and pumped at the refinery, terminal, or hot mix plant facility. Measured viscosity from this procedure can be used to develop temperature viscosity charts for estimating mixing and compaction temperatures for use in hot mix asphalt mix design.

6. APPARATUS

6.1. *Oven*—An oven capable of maintaining any desired temperature setting from room temperature to 260°C to within ±3°C.

6.2. *Thermometers*—Thermometers having a range from 60 to over 200°C and readable to 0.2°C.

6.3. *Balance*—A balance with a capacity of 2000 g readable to 0.1 g for determining the mass of asphalt binder.

6.4. *Cylindrical Spindles* of various sizes for measurement of asphalt binders of different viscosities.

6.5. *Rotational Viscometer* capable of measuring the torque required to rotate the selected spindle at a selected constant speed while submerged in asphalt at constant desired test temperature and should display the viscosity in Pascal seconds automatically.

6.6. *Temperature Controller*—A proportional temperature controller capable of maintaining the specimen temperatures ±1.0°C for test temperatures ranging from 60 to 165°C or greater.

7. MATERIALS

7.1. Solvent (such as Mineral Spirits or Varsol) or a degreasing spray cleaner formulated for cleaning the sample holder, spindles, and accessories.

8. HAZARDS

8.1. Use standard laboratory safety procedures required for handling the hot asphalt binder and required safety procedures when cleaning with solvents or degreasers.

9. PREPARATION OF APPARATUS

9.1. The rotational viscometer must be leveled to function properly. A bubble-type level is normally located on top of the viscometer and is adjusted by using leveling screws located on the base. If the torque controller and thermal chamber are separate units, both should be leveled in accordance with the device manufacturer's instructions.

10. CALIBRATION AND STANDARDIZATION

10.1. The accuracy of the rotary transducer is checked using a reference fluid (Newtonian fluid) of known viscosity at various temperatures. The reference fluid shall be certified to be Newtonian in behavior over the full range of expected test temperatures and shear rates. The viscosity measured should be within ±2 percent or the rotary transducer requires recalibration.

10.2. The accuracy of the temperature reading of the temperature controller is checked by placing an asphalt sample in the testing chamber and equilibrating to a given temperature. The indicated temperature shall be verified by using a NIST-traceable measuring device as defined by ASTM E1.

11. PREPARATION OF SAMPLES AND TEST SPECIMENS

11.1. *Preparing Test Samples*—Unaged asphalt and modified asphalt binders are obtained according to R 66.

11.1.1. Anneal the asphalt binder from which the specimen is obtained by heating until sufficiently fluid to pour. Annealing prior to testing removes reversible molecular associations (steric hardening) that may occur during normal storage at ambient temperature.

Note 1—Minimum pouring temperature that produces a consistency equivalent to that of SAE 10W30 motor oil (readily pours but not overly fluid) at room temperature is recommended. The specific temperature will depend on the grade of binder and its prior aging history, if any. Temperatures less than 135°C are desirable; however, temperatures above 135°C may be required for some modified asphalt binders or heavily aged binders.

12. PROCEDURE

12.1. Read and understand the information in the rotational viscometer manufacturer's operating manual before proceeding.

12.2. Turn on the rotational viscometer and proportional temperature controller unit.

12.3. Preheat the sample holder with the sample chamber and the selected cylindrical spindle according to the manufacturer's recommendation.

12.4. Set the proportional temperature controller to desired test temperature.

12.5. Heat the required amount of asphalt binder as recommended by the manufacturer for testing according to Section 11.1.1.

12.6. When the proportional temperature controller reads the desired test temperature, remove the sample holder, and add the required amount of asphalt into the sample chamber.

12.7. Insert the sample chamber into the proportional temperature controller unit.

12.8. Insert a preheated spindle and attach it to the viscometer using the necessary coupling. Gently lower the spindle into the asphalt so that asphalt covers the upper conical portion of the spindle. This procedure may vary based on the manufacturer's recommendations.

12.9. Bring the asphalt sample to the desired temperature within approximately 30 min. Set the viscometer speed at 20 rpm and set the display to read the viscosity in Pascal seconds (Pa·s). This operation may be performed manually or by using a software program. The viscometer speed may be set higher than 20 rpm if it is expected that the observed torque will be out of range at 20 rpm.

12.10. Allow the asphalt sample to equilibrate at the desired test temperature for a minimum of 10 min. Begin the spindle rotation during the 10-min temperature equilibration period. Allow the readings to stabilize before recording any viscosity measurements. If the observed torque is out of range for the selected spindle and speed, change the spindle or speed based on the manufacturer's recommendations for the anticipated viscosity. If a different spindle is used, restart the test with a new sample.

12.11. Start the test after the asphalt sample has reached the specified temperature and equilibrated and the viscosity readings have stabilized, as required in Sections 12.9 and 12.10.

12.12. Measure the viscosity at 1-min intervals for a total of 3 min.

12.13. Follow the procedure in Sections 12.1 to 12.12 for other temperatures.

13. CALCULATION OF RESULTS

13.1. The viscosity is reported as the average of three readings. If the digital output of the rotational viscometer viscosity is in units of centipoise (cP), the following factor is used to convert to Pascal-seconds:

$$10\ \mathrm{P} = 1\ \mathrm{Pa\cdot s} \qquad (1)$$

$$1\ \mathrm{cP} = 1\ \mathrm{mPa\cdot s} \qquad (2)$$

Multiply viscosity in centipoise by 0.001 to obtain the viscosity in Pa·s.

14. REPORT

14.1. *Report the following information*:

14.1.1. The date and time of the test;

14.1.2. The test temperature to the nearest 1°C;

14.1.3. The speed in rpm;

14.1.4. The size of the spindle used;

14.1.5. The torque in percent; and

14.1.6. The average viscosity in Pa·s.

15. PRECISION AND BIAS

15.1. *Precision*—Criteria for judging the acceptability of viscosity results obtained by this method are given in Table 1.

15.1.1. *Single-Operator Precision (Repeatability)*—The figures in Column 2 of Table 1 are the coefficients of variation that have been found to be appropriate for the conditions of test described in Column 1. Two results obtained in the same laboratory, by the same operator using the same equipment, in the shortest practical period of time, should not be considered suspect unless the difference in the two results, expressed as a percent of their mean, exceeds the values given in Table 1, Column 3.

15.1.2. *Multilaboratory Precision (Reproducibility)*—The figures in Column 2 of Table 1 are the coefficients of variation that have been found to be appropriate for the conditions of test described in Column 1. Two results submitted by two different operators testing the same material in different laboratories shall not be considered suspect unless the difference in the two results, expressed as a percent of their mean, exceeds the values given in Table 1, Column 3.

Table 1—Precision Estimates

Condition	Coefficient of Variation (1s%)[a]	Acceptable Range of Two Test Results (d2s%)[a]
Single-operator precision:		
Average viscosity (Pa·s)	1.2	3.5
Multilaboratory precision:		
Average viscosity (Pa·s)	4.3	12.1

[a] These values represent the 1s% and d2s% limits described in ASTM C670.

Note 2—The precision estimates given in Table 1 are based on the analysis of test results from eight pairs of AMRL proficiency samples. The data analyzed consisted of results from 142 to 202 laboratories for each of the eight pairs of samples. The analysis included five binder grades: PG 52-34, PG 64-16, PG 64-22, PG 70-22, and PG 76-22 (SBS modified). Unmodified binder average viscosity results ranged from 0.272 Pa·s to 0.719 Pa·s. The modified binder average viscosity results ranged from 1.621 Pa·s to 1.638 Pa·s. The details of this analysis are in the final report for NCHRP Project No. 9-26, Phase 3.

Note 3—As an example, two tests conducted on the same material yield viscosity results of 0.500 Pa·s and 0.510 Pa·s, respectively. The average of these two measurements is 0.505 Pa·s. The acceptable range of results is then 3.5 percent of 0.505 Pa·s or 0.018 Pa·s. As the difference between 0.500 Pa·s and 0.510 Pa·s is less than 0.018 Pa·s, the results are within the acceptable range.

15.2. *Bias*—No information can be presented on the bias of the procedure because no material having an accepted reference value is available.

16. KEYWORDS

16.1. Asphalt binder; viscosity.