



Designation: D 4016 – 93

## Standard Test Method for Viscosity of Chemical Grouts by Brookfield Viscometer (Laboratory Method)<sup>1</sup>

This standard is issued under the fixed designation D 4016; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the determination of viscosity of catalysed chemical grouts with the Brookfield viscometer (laboratory method), over the range from 1.0 to 1000 cP (0.001 to 1 Pa·s).

1.2 *This standard does not purport to address all of the safety problems, 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. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *coefficient of viscosity*—the ratio between the applied shear stress and the rate of shear. This coefficient is a measure of the resistance to flow of the liquid. It is commonly called the viscosity of the liquid. The cgs unit of viscosity is 1 g/cm·s (1 dyn/s cm<sup>2</sup>) and is called a poise (P). Viscosities of thin liquids are normally given in hundredths of a poise or centipoises (cP). The SI unit of viscosity is 1 Pa·s (1 N·s/m<sup>2</sup>) and is equal to 10 P, or 1000 cP.

2.1.2 *Newtonian liquid*—a liquid in which the shear stress is proportional to the rate of shearing strain. This constant ratio is the viscosity. Non-Newtonian behavior can be determined with the Brookfield instrument by taking measurements at different spindle speeds.

### 3. Summary of Test Method

3.1 A rotating spindle is immersed in a container of catalysed chemical grout. An index to the viscosity is read directly on the instrument scale.

### 4. Significance and Use

4.1 This test is intended for materials that will penetrate soil voids and rock fissures. Viscosity alone is not necessarily an exact index of grout penetrability.

### 5. Apparatus

5.1 *Brookfield Viscometer*—Any model whose lower limit of effective measurement is less than the value of the sample. Models LVF and LVT should be used for measurements above 20 cP (20 mPa·s), and for measurements from 1 to 20 cP (1 to 20 mPa·s) with the addition of a Model UL adapter. Models RV, RT, HA, and HB may be used for measurements above 100 cP (100 mPa·s).

NOTE 1—The UL adapter may be used for better accuracy in the 20 to 100-cP (20 to 100-mPa·s) range also.

5.2 *Griffin Beaker, 600-cm<sup>3</sup>*, low-form used as the container for the sample. Beaker material must not react with the grout. Glass beakers are not acceptable for silicates. Stainless steel beakers are acceptable for all materials.

5.3 *Calibrated Liquid-in-Glass Thermometers*, accurate to  $\pm 1.0^\circ\text{F}$  ( $0.5^\circ\text{C}$ ), or any other thermometric device of equal accuracy.

NOTE 2—Glass thermometers should not be used with silicates.

5.4 *Temperature-Control Bath*, for work at other than ambient temperature, and large enough to hold the sample container. Any bath that will maintain its temperature within  $\pm 1.0^\circ\text{F}$  ( $0.5^\circ\text{C}$ ) during the test period is adequate.

NOTE 3—Grout temperature must equal bath temperature at the start of the test. Temperature rise due to chemical reaction does not invalidate the test data.

### 6. Sample Preparation

6.1 The temperature of the grout components at time of testing shall be  $68 \pm 1^\circ\text{F}$  ( $20 \pm 0.5^\circ\text{C}$ ).

NOTE 4—Alternatively, three or more tests at various temperatures may be taken to define a viscosity versus temperature relationship. It is desirable to have such tests span the anticipated ground temperature.

6.2 Viscosity data should be taken on catalysed grout solution that contains all of the components normally used for field application.

### 7. Procedure

7.1 Prepare the grout components separately and bring them to the required temperature.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization With Admixtures.

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0.5 to 6

200 to 1000

7.2 When not using the UL adapter attach the No. 1 spindle to the lower shaft.

7.2.1 When using the UL adapter attach the locating channel to the viscometer. Assemble the spindle, extension link, and coupling nut. Thread the coupling nut onto the viscometer spindle coupling. Guide the tube over the spindle. Thread the lower mounting screw into the tube collar.

NOTE 5—For more detailed assembly instructions, refer to the manufacturer’s operation manual.

7.3 Catalyse the grout in a 600-cm<sup>3</sup> beaker. For materials whose gel time range is between 10 and 30 min, gel time should be set at about 20 min. Instrument readings of viscosity (versus time) should be taken at approximately every two minutes.

7.3.1 For materials whose gel time range is less than 10 min, a gel time should be set between 50 and 100 % of gel time range, and readings taken at least every 2 min or, if possible, at 1-min intervals.

7.3.2 For materials whose gel time range is over 30 min, a gel time should be selected at least 25 % above minimum, and readings taken at approximately equal time intervals to permit at least five readings prior to gelation.

NOTE 6—For materials whose normal setting time is modified by prolonged agitation (this includes many silicate and acrylamide grouts) only one reading per sample should be taken, and multiple samples used to define the viscosity-time data.

7.4 Insert the spindle or UL adapter into the group up to the reference mark and level the viscometer.

7.5 Select the highest spindle speed that will give a viscometer reading between 20 % and 80 % of scale. The following table may be used as a selection guide.

With Model UL Adapter	
rpm	Range, cP or mPa-s
50 to 100	0 to 10
20 to 50	10 to 30
10 to 20	20 to 50
1 to 10	50 to 100
Without UL Adapter	
rpm	Range, cP or mPa-s
2 to 30	20 to 100
0.5 to 20	50 to 200
0.5 to 12	100 to 500

7.5.1 For all samples whose gel time permits more than one reading, at least one shall be taken at a different spindle speed, from that originally selected. If apparent viscosities differ by more than 20 % at different spindle speeds, the grout shall be reported as non-Newtonian.

NOTE 7—For non-Newtonian fluids it is recommended that, where possible, sufficient readings be taken so that a chart of spindle speed versus “effective” viscosity may be reported.

7.6 Depress the clutch and turn on the motor. Release the clutch and allow the dial to rotate until the pointer stabilizes.

NOTE 8—At speeds above 4 rpm, 20 to 30 s will generally be required. At slower speeds, it may take longer.

## 8. Report

8.1 The following data shall be included in the report:

8.1.1 Composition of the grout, listing each component, and its weight percentage of the total solution. Composition by volume is also acceptable, if pertinent solution concentrations and densities are noted.

8.1.2 Temperature of the test sample, just prior to the viscosity measurement.

8.1.3 Gel time of the sample.

NOTE 9—For the purpose of this test, change from liquid to gel may be considered to occur when the liquid becomes too thick to pour out of the sample container.

8.1.4 Sample viscosity in cP (mPa-s) for grouts with very short gel times, or preferably, a plot of viscosity versus time.

## 9. Precision

9.1 *Precision*—Data are being evaluated to determine the precision of this test method. In addition Subcommittee D18.16 is seeking pertinent data from users of this test method.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

## 10. Keywords

10.1 Brookfield viscometer; chemical grout; coefficient of viscosity; grouting; Newtonian fluids; non-Newtonian fluids

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