Designation: D1545 – 13 (Reapproved 2017)

Standard Test Method for Viscosity of Transparent Liquids by Bubble Time Method[1]

This standard is issued under the fixed designation D1545; 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.

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

1. Scope

1.1 This test method covers the determination of the viscosity in bubble seconds by timing. The bubble seconds are approximately equal to stokes for most liquids.

1.2 The test method is applicable to transparent liquids that are free from crystalline or gel particles.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions:*

2.1.1 *viscosity, n*—the resistance experienced by one portion of a liquid moving over another portion of the liquid. The absolute unit of viscosity in the cgs, centimeter-gram-second, system is the poise which is expressed as dyne-seconds per square centimetre. Stokes are equal to poises divided by density. The absolute SI, International System of Units (metric system), viscosity unit is the pascal-second.

3. Apparatus

3.1 *Constant-Temperature Bath*—Any suitable bath capable of maintaining temperature at 25 ± 0.1°C with water as the bath medium.

3.2 *Standard Viscosity Tubes* of clear glass and with flat bottoms, 10.65 ± 0.025 mm in inside diameter; 114 ± 1 mm in outside length. Plainly legible lines shall be located as follows (Note 1):

27 ± 0.5 mm
100 ± 0.5 mm
108 ± 0.5 mm

The distance between the first and second lines shall be 73 ± 0.5 mm.

NOTE 1—All distances shall be measured from the outside bottom of the tube.

3.3 *Reference Standards*—A series of standard viscosity tubes (3.2) filled with transparent liquids having predetermined viscosities in centistokes and bubble seconds as listed in Table 1. The standards are listed alphabetically from the lowest viscosity to the highest viscosity standard.

3.4 *Timing Device*—Stopwatch or electric stop clock capable of being read to a precision of 0.1 s.

3.5 *Tube Racks,* capable of inverting one or more viscosity tubes 180° to within 1° of a vertical position while rack and tubes are immersed in the constant temperature bath.

3.6 *Viscosity Tube Corks,* No. 2 short.

4. Procedure

4.1 Fill a standard viscosity tube with the material to be tested to approximately level with the 108-mm line.

4.2 Transfer the tube to a constant 25°C temperature bath with the cork loosely inserted. Hold at this temperature for 10 min.

NOTE 2—Adequate control of the temperature bath is essential. A variation of 0.1°C in the temperature of the bath will cause a 1 % variation in the timed bubble travel.

4.3 At the end of 10 min adjust the level of the liquid so that the bottom meniscus will be level with the 100-mm line. Insert the cork so that the bottom of the cork is on the level with the 108-mm line. This will ensure a bubble of suitable and uniform size.

4.4 Insert the tube in the rack and immerse in the 25°C water bath. Allow the tube(s) to stand with cork down in the bath a minimum of 20 min before determining the viscosity.

[1] This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.24 on Physical Properties of Liquid Paints & Paint Materials.

Current edition approved Dec. 1, 2017. Published December 2017. Originally approved in 1958. Last previous edition approved in 2013 as D1545 – 13. DOI: 10.1520/D1545-13R17.

TABLE 1 Recommended numerical Standards for Comparator Viscosity Tubes[A]

Gardner-Hodlt Letter	Minimum (Sec)	Target (Sec)	Maximum (Sec)	Kinematic Viscosity (cST)
A5	0.641	0.650	0.654	5.1
A4	0.659	0.663	0.682	7.1
A3	0.701	0.720	0.736	14.0
A2	0.751	0.767	0.785	21.3
A1	0.802	0.820	0.845	31.0
A	0.908	0.936	0.961	53.6
B	0.987	1.012	1.042	68.8
C	1.175	1.211	1.247	92.7
D	1.272	1.303	1.342	102.9
E	1.453	1.498	1.543	122.7
F	1.620	1.670	1.720	151.9
G	1.795	1.850	1.906	160.0
H	2.086	2.150	2.207	210.8
I	2.263	2.320	2.390	224.2
J	2.668	2.750	2.833	268.2
K	2.927	3.015	3.072	287.9
L	3.128	3.185	3.272	302.3
M	3.358	3.445	3.527	335.4
N	3.608	3.690	3.785	345.2
O	3.880	3.975	4.062	377.9
P	4.148	4.235	4.337	408.8
Q	4.438	4.540	4.642	441.8
R	4.743	4.845	4.990	467.4
S	5.142	5.290	5.449	517.7
T	5.820	6.000	6.180	547.2
U	6.581	6.785	6.989	665.9
V	8.701	8.970	9.239	889.2
W	10.85	11.19	11.52	1073.0
X	14.36	14.80	15.24	1200.0
Y	17.85	18.40	18.96	1737.0
Z	22.96	23.67	24.38	2289.0
Z1	29.77	30.69	31.61	2909.0
Z2	38.95	40.15	41.36	4056.0
Z3	46.56	48.00	49.44	4840.0
Z4	70.06	72.23	74.39	7241.0
Z5	102.01	105.16	108.32	9917.0
Z6	153.09	157.82	162.56	15080.0
Z7	409.02	421.67	434.32	40650.0
Z8	741.25	764.17	787.10	73280.0
Z9	925.96	954.60	983.24	91500.0
Z10	1202.97	1240.17	1277.38	119000.0

[A] 1 Stoke = 100 centistokes (cST).

Note—Bubble times based on 25°C temperature. A digital camera with image software is used to determine the bubble times.

NOTE 3—For viscosities of liquids that have a timed bubble travel of 4 s or less, more precise results can be obtained by comparison against reference standards having a predetermined viscosity or timed bubble travel.

4.5 To read, invert the tube quickly and determine the time required for the bubble to rise in seconds. When determining the time in seconds start the timing device when the top of the bubble becomes tangent to the 27-mm line on the tube. Stop the timing when the top of the bubble becomes tangent with the 100-mm line. This gives a 73-mm timed bubble travel. All timings shall be made with the tube in an exact vertical position.

NOTE 4—Positioning of the tube in a vertical position is mandatory. A tube one radius off the vertical will give an error of approximately 10 % in the time of bubble travel.

5. Report

5.1 Report the following information:

5.1.1 The viscosity obtained by the timing method expressed as "bubble seconds" or "approximate stokes."

NOTE 5—The time in seconds or "bubble seconds" is an approximate measurement of stokes when the bubble time method is applied to most raw materials and finished products encountered by the paint, varnish, and lacquer industries. This relationship does not hold for silicones or water dispersions of gums or similar materials. Viscosity results by this test method are influenced by non-Newtonian behavior and by surface tension. Other variations on bubble-tube viscometers are described in ASTM STP 500, Section 3.2.9.[2]

6. Precision and Bias

6.1 *Precision*—On the basis of an interlaboratory study[3] of this test method in which ten laboratories tested liquids ranging in viscosity from 4.5 to 440 St, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

6.1.1 Two results obtained by the same operator should be considered suspect if they differ by more than 4.9 % relative.

[2] *Paint Testing Manual, ASTM STP 500*, ASTM, 1972.

[3] See Holt, K. E., *Proceedings*, ASTM, Vol 57, 1957, pp. 297–300, and *Official Digest*, Federation of Societies for Paint Technology, Vol 30, May 1958, pp. 540–543.

6.1.2 Two results, each the mean of duplicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 9.0 % relative.

6.2 *Bias*—No information can be presented on the bias of this test method because no materials having an accepted reference value is available.

7. Keywords

7.1 Gardner-Holdt; GH viscosity; viscosity