Designation: D562 − 10 (Reapproved 2014)

Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer[1]

This standard is issued under the fixed designation D562; 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 measurement of Krebs Unit (KU) viscosity to evaluate the consistency of paints and related coatings using the Stormer-type viscometer.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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:*[2]

E1 Specification for ASTM Liquid-in-Glass Thermometers

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *consistency, n*—load in grams to produce a rotational frequency of 200 r/min (Stormer Viscometer).

3.1.2 *Krebs units (KU), n*—values of a scale commonly used to express the consistency of paints generally applied by brush or roller.

3.1.2.1 *Discussion*—This scale is a function of the "load to produce 200-r/min" scale.

4. Summary of Test Method

4.1 The load required to produce a rotational frequency of 200 r/min for an offset paddle rotor immersed in a paint is determined.

5. Significance and Use

5.1 This test method provides values that are useful in specifying and controlling the consistency of paints, such as consumer or trade sales products.

METHOD A

6. Apparatus

6.1 *Viscometer,* Stormer, with the paddle-type rotor as illustrated in Fig. 1 and Fig. 2. The stroboscopic timer attachment in Fig. 1 can be removed and the instrument used without it but with a sacrifice of speed and accuracy. The stroboscopic timer gives the 200 r/min reading directly.

6.2 *Container,* 500-mL (1-pt), 85 mm (3⅜ in.) in diameter.

6.3 *Thermometer*—An ASTM Stormer Viscosity thermometer having a range from 20 to 70°C and conforming to the requirements for Thermometer 49C, as prescribed in Specification E1. In addition, temperature measuring devices such as non-mercury liquid-in-glass thermometers, thermocouples, or platinum resistance thermometers that provide equivalent or better accuracy and precision, that cover the temperature range for thermometer 49C, may be used.

6.4 *Stopwatch,* or suitable timer measuring to 0.2 s.

6.5 *Weights,* a set covering the range from 5 to 1000 g.

7. Materials

7.1 Two standard oils, calibrated in absolute viscosity (poise), that are within the viscosity range of the coatings to be measured. These oils should differ in viscosity by at least 5 P.

NOTE 1—The normal range of the Stormer is covered by oils having viscosities of 4 P (70 KU), 10 P (85 KU), and 14 P (95 KU).

7.1.1 Suitable standards are silicone, hydrocarbon, linseed, and castor oils. Silicone and hydrocarbon oils calibrated in poises are commercially available. Uncalibrated linseed and castor oils may be calibrated with any apparatus that provides measurements of absolute 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 and Paint Materials.

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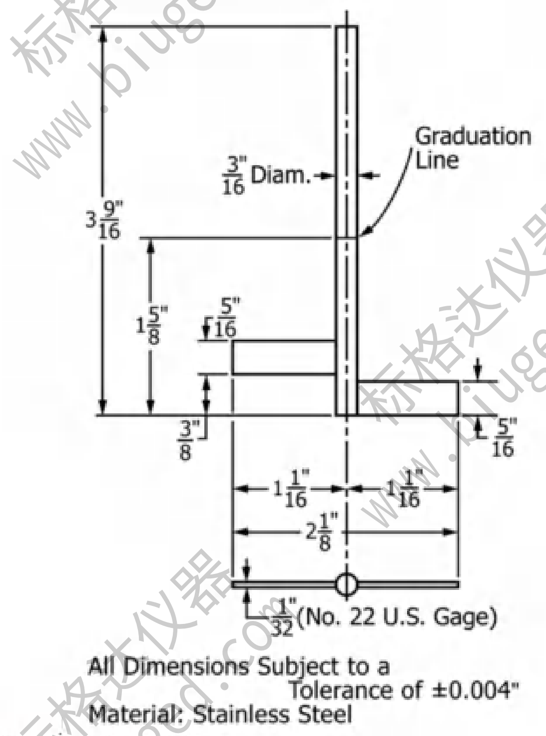
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

FIG. 1 Stormer Viscometer with Paddle-Type Rotor and Stroboscopic Timer



NOTE 1—1 in. = 25.4 mm.

FIG. 2 Paddle-Type Rotor for Use With Stormer Viscometer

7.1.2 Assign a value of load to produce 200 r/min to each oil by converting its viscosity value in poises to load in grams by the following equation:[3]

$$L = (610O + 906.6\,D)/30$$

where:

O = viscosity of oil in poises and
D = density of oil.

8. Calibration[4]

8.1 Remove the rotor and weight carrier from the viscometer. Make sure the string is wound evenly on the drum and does not overlap itself.

8.2 Attach a 5-g weight onto the string and then release the brake. If the viscometer starts to run from this dead start and continues to run through several revolutions of the string drum, it is satisfactory for use. If it does not start unaided when the 5-g weight is applied, the instrument should be reconditioned.

8.3 Check the dimensions of the paddle-type rotor. They should be within 0.1 mm (±0.004 in.) of the dimensions shown in Fig. 2.

8.4 Select two standard oils having assigned values of load to produce 200 r/min within the range of the values expected for the coatings to be measured (see 7.1).

8.5 Adjust the temperature of the standard oils to 25 ± 0.2°C. The temperature of the Stormer apparatus should be the same. If the specified temperature cannot be obtained, record the temperature of the oil at the beginning and end of test to 0.2°C.

8.6 Determine the load in grams to produce 200 r/min with each of the two oils, using either Procedure A described in Section 9 or Procedure B described in Section 10.

8.6.1 If the oil temperature was not at 25 ± 0.2°C during the test, correct the measured load in grams for the deviation from that temperature.

NOTE 2—Load corrections for deviations of oil temperature from the specified temperature can be made by means of a previously established plot of load versus oil temperature (see Appendix X1).

8.7 If the measured load (corrected for any temperature deviation from standard) is within ±15 % of the assigned load values for the oils, the Stormer apparatus can be considered to be in satisfactory calibration.

9. Procedure A (Without Stroboscopic Attachment)

9.1 Thoroughly mix the sample and strain it into a 500-mL (1-pt) container to within 20 mm (¾ in.) of the top.

9.2 Bring the temperature of the specimen to 25 ± 0.2°C and maintain it at that temperature during the test. The temperature of the Stormer apparatus should be the same.

9.2.1 If the specified temperature cannot be obtained, record the temperature of the specimen at the beginning and end of test to 0.2°C.

9.3 When the temperature of the specimen has reached equilibrium, stir it vigorously, being careful to avoid entrapping air, and place the container immediately on the platform

[3] Geddes, J. A., and Dawson, D. H., "Calculation of Viscosity From Stormer Viscosity Data," *Industrial and Engineering Chemistry*, Vol 34, 1942, p. 163.

[4] Jackson, C. F., and Madson, W. H., "A Method for the Standardization of Krebs Modified Stormer Viscometers," *ASTM Bulletin*, No. 161, 1949.

of the viscometer so that the paddle-type rotor is immersed in the material to the mark on the shaft of the rotor.

9.4 Place weights on the hanger of the viscometer and determine a load that will produce 100 revolutions in the range of 25 to 35 s.

9.5 Using the information gained in 9.4, select two loads that will provide two different readings (time to give 100 revolutions) within the range of 27 to 33 s. Make these measurements from a running start, that is, permit the rotor to make at least 10 revolutions before starting the timing for 100 revolutions.

9.6 Repeat the measurements outlined in 9.5 until two readings for each load are obtained that agree within 0.5 s.

10. Procedure B (With Stroboscopic Timer)

10.1 Follow Procedure A (9.1 – 9.3) for the preparation of the specimen.

10.2 Connect the lamp circuit of the stroboscopic attachment to an electrical power source.

10.3 Place weights on the hanger of the viscometer and determine a load that will produce 100 revolutions in the range from 25 to 35 s.

10.4 Using the information gained in 10.3, select a weight (to the nearest 5 g) that will produce the 200-r/min pattern (Fig. 3) on the stroboscopic timer, that is, where the lines appear to be stationary.

10.4.1 Lines moving in the direction of paddle rotation indicate a speed greater than 200 r/min and therefore, weight should be removed from the hanger. Conversely, lines moving opposite to direction of paddle rotation indicate a speed less than 200 r/min and weight should be added.

NOTE 3—There are other patterns that appear at speeds other than 200 r/min (See Fig. 4). The pattern for 200 r/min should be determined before running any tests.

10.5 Repeat the determination in 10.4 until a consistent value of load is obtained (that is, to within 5 g).

11. Calculation

11.1 *Procedure A:*

11.1.1 Calculate the load to within 5 g, to produce 100 revolutions in 30 s by interpolating between the load weights recorded for the readings made between 27 and 33 s for 100 revolutions.

11.1.2 Correct the load determined for any deviation of the specimen temperature from the specified temperature (see Appendix X1).

11.1.3 If desired, determine from Table 1 the KU corresponding to the load to produce 100 revolutions in 30 s.

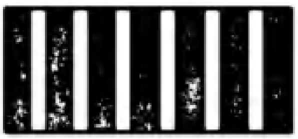


FIG. 3 Stroboscopic Lines Opening When Timer is Adjusted to Exactly 200 r/min

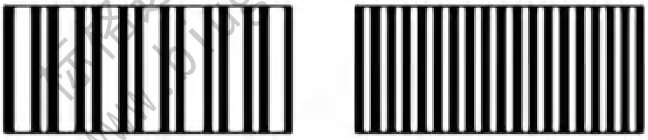


FIG. 4 Stroboscopic Lines Appearing as Multiples that May be Observed Before 200-r/min Reached

NOTE 4—Table 1 has been constructed so that it is not necessary to interpolate between loads to obtain the KU corresponding to the load to produce 100 revolutions in 30 s. The table provides KU values computed for a range of 27 to 33 s for 100 revolutions.

11.2 *Procedure B:*

11.2.1 If desired, determine from Table 2 the KU value corresponding to the load to produce 200 r/min.

12. Report

12.1 Report the following information:

12.1.1 The load in grams to produce 200 r/min (100 revolutions in 30 s),

12.1.2 The calculated KU,

12.1.3 The temperature of the specimen during the test and whether a correction was applied for any deviation from 25°C, and

12.1.4 Whether Procedure A or Procedure B was used.

13. Precision and Bias

13.1 *Precision*—On the basis of a study in which determinations were made on five paints by two operators at each of five laboratories on each of two different days; the within-laboratory coefficient of variation was found to be 3 % in load grams or 1.5 % in KU, and the between-laboratory coefficient of variation was found to be 10 % in load grams or 4 % in KU.

13.1.1 The following criteria should be used for judging the acceptability of results at the 95 % confidence level.

13.1.1.1 *Repeatability*—Two results each the mean of two measurements, obtained on the same material by the same operator at different times should be considered suspect if they differ by more than 1.7 % in KU.

13.1.1.2 *Reproducibility*—Two results, each the mean of two measurements on the same material, obtained by operators in different laboratories should be considered suspect if they differ by more than 5.1 % in KU.

METHOD B (Digital Display Stormer-Type Viscometer)

14. Apparatus

14.1 *Viscometer, Digital Display,* with the paddle-type rotor as illustrated in Fig. 1 and Fig. 5.

14.2 *Container,* 500 mL (1 pt), 85 mm (3 ⅜ in. in diameter.

14.3 *Thermometer,* ASTM Stormer viscosity thermometer having a range from 20 to 70°C and conforming to the requirements for Thermometer 49C as prescribed in Specification E1.

15. Materials

15.1 *Standard Oils,* two, calibrated in absolute viscosity that are within the viscosity range of the coatings to be measured. These oils should differ in viscosity by at least 25 KU.

TABLE 1 Krebs' Stormer Chart with Interpolations

Seconds for 100 Revolutions	Load, g																																			
	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600	625	650	675	700	725	750	775	800	825	850	875	900	950	1000
	Krebs Units																																			
27	49	57	63	69	74	79	83	86	89	92	95	97	100	102	104	106	109	111	113	114	116	118	120	121	123	124	126	127	129	130	131	132	133	134	136	138
28	51	59	65	70	75	80	84	87	90	93	96	98	100	102	105	107	110	112	114	115	117	118	120	121	123	124	126	127	129	130	131	132	133	134	137	139
29	53	60	66	71	76	81	85	88	91	94	97	99	101	103	105	107	110	112	114	115	117	119	121	122	124	125	127	128	130	131	132	133	134	135	137	139
30	54	61	67	72	77	82	86	89	92	95	98	100	102	104	106	108	110	112	114	116	118	120	121	122	124	125	127	128	130	131	133	134	135	136	138	140
31	55	62	68	73	78	82	86	90	93	95	98	100	102	104	106	108	111	113	115	116	118	120	122	123	125	126	128	129	131	132	133	134	135	136	138	140
32	56	63	69	74	79	83	87	90	93	96	99	101	103	105	107	109	111	113	115	116	118	120	122	123	125	126	128	129	131	132	133	134	135	136	138	140
33	57	64	70	75	80	84	88	91	94	96	99	101	103	105	107	109	112	114	116	117	119	121	122	123	125	126	128	129	131	132	134	135	136	137	139	141

TABLE 2 Krebs Units Corresponding to Load Required to Produce 200-r/min Rotation
(For use with Stormer Viscometer equipped with Stroboscopic Timer)

Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU	Grams	KU
		100	61	200	82	300	95	400	104	500	112	600	120	700	125	800	131	900	136	1000	140
		105	62	205	83																
		110	63	210	83	310	96	410	105	510	113	610	120	710	126	810	132	910	136	1010	140
		115	64	215	84																
		120	65	220	85	320	97	420	106	520	114	620	121	720	126	820	132	920	137	1020	140
		125	67	225	86																
		130	68	230	86	330	98	430	106	530	114	630	121	730	127	830	133	930	137	1030	140
		135	69	235	87																
		140	70	240	88	340	99	440	107	540	115	640	122	740	127	840	133	940	138	1040	140
		145	71	245	88																
		150	72	250	89	350	100	450	108	550	116	650	122	750	128	850	134	950	138	1050	141
		155	73	255	90																
		160	74	260	90	360	101	460	109	560	117	660	123	760	129	860	134	960	138	1060	141
		165	75	265	91																
70	53	170	76	270	91	370	102	470	110	570	118	670	123	770	129	870	135	970	139	1070	141
75	54	175	77	275	92																
80	55	180	78	280	93	380	102	480	110	580	118	680	124	780	130	880	135	980	139	1080	141
85	57	185	79	285	93																
90	58	190	80	290	94	390	103	490	111	590	119	690	124	790	131	890	136	990	140	1090	141
95	60	195	81	295	94																

FIG. 5 Digital Stormer-Type Viscometer

15.2 *Suitable Hydrocarbon Oils,* calibrated in KU and traceable to NIST, available commercially.

16. Calibration

16.1 Check the dimensions of the paddle-type rotor. They should be within ±0.1 mm (0.004 in.) of the dimensions shown in Fig. 2.

16.2 Select two standard oils having viscosities in KU within the range of the values expected for the coatings to be measured (see 15.1).

16.3 Adjust the temperature of the standard oils to 25 ± 0.2°C. The temperature of the viscometer should be the same. If the specified temperature cannot be obtained, record the temperature of the oil at the beginning and end of the test to 0.2°C.

16.4 If the oil temperature was not at 25 ± 0.2°C during the test, correct the measured KU viscosity for the deviation from that temperature.

NOTE 5—Corrections for deviations of oil temperature from the specified temperature can be made by means of a previously established plot of load grams versus oil temperature (see Appendix X1).

16.5 If the measured viscosity (corrected for any temperature deviation from standard) is within ±5 % of the specified KU values for the standard oils, the viscometer can be considered to be in satisfactory calibration.

17. Procedure

17.1 Thoroughly mix the specimen and pour into a 500–mL (1–pt) container to within 20 mm (¾ in.) of the top.

17.2 Bring the temperature of the specimen to 25 ± 0.2°C, and maintain it at that temperature during the test. The temperature of the viscometer should be the same.

17.3 If the specified temperature cannot be obtained, record the temperature of the specimen at the beginning and end of the test to 0.2°C.

17.4 When the temperature of the specimen has reached equilibrium, stir it vigorously, being careful to avoid entrapping air, move the operating handle to the top position, pull the front locator out and place the container immediately on the base of the viscometer against the locating pins and release the front locator locking and centering the can.

17.5 Turn on the main power switch and select either KU or Gram (gm) display. Be sure that the HOLD reading switch is in the up position.

17.6 Move the operating handle to the lower (immersing the paddle spindle into the specimen). The fluid should be close to the immersion groove on the paddle shaft. The paddle will start rotating when it is within about 12 mm (½ in.) of the lower position.

17.7 Wait 5 s for the display reading to stabilize.

17.8 Press the HOLD reading switch down to "hold" the display and use the display selector knob to display KU or gram units, or both.

17.9 Raise the operating handle to the top position, and let the specimen drain from the paddle spindle.

17.10 Loosen the thumb screw and remove the paddle spindle for cleaning.

18. Report

18.1 Report the following information:

18.1.1 The measured Krebs Units (KU) and the Grams (gm).

18.1.2 The temperature of the specimen during the test and whether a correction was applied for any deviation from 25°C.

19. Precision and Bias

19.1 *Precision*—On the basis of a study in which measurements were made on five paints by two operators in each of six laboratories (five with Brookfield KU-1 viscometer and one with an electronic Stormer viscometer) on each of two different days, the following criteria should be used for judging the acceptability of results at the 95 % confidence level.

19.1.1 *Repeatability*—Two results, each the mean of two measurements on the same material by the same operator at different times, should be considered suspect if they differ by more than 2.0 % in KU.

19.1.2 *Reproducibility*—Two results, each the mean of two measurements on the same material, obtained by operators in different laboratories should be considered suspect if they differ by more than 5.0 % in KU.

19.2 *Bias*—Since there is no accepted reference material for this test method, bias cannot be determined.

20. Keywords

20.1 consistency; Krebs units (KU); Stormer-type viscometer; viscosity

APPENDIX

(Nonmandatory Information)

X1. EFFECT OF SPECIMEN TEMPERATURE ON STORMER CONSISTENCY

X1.1 For maximum accuracy in determining the effect of specimen temperature on consistency, measurements should be performed at three different specimen temperatures covering the range of interest. The change in load or KU per 1°C change can be determined from these results.

X1.2 It has been observed that the consistency of an oil is considerably more sensitive to temperature than is the consistency of a paint.

X1.3 Some typical effects of temperatures on the consistency of oils and paints are given below:

	Mean Value at 25°C		Change per 1°C Change	
	Load, g	KU value	Load, g	KU value
Hydrocarbon oil No. 1	149	72	14	2.5
Hydrocarbon oil No. 2	217	85	18	2.0
Hydrocarbon oil No. 3	286	93	11	1.5
Bodied linseed oil	195	81	8	1.0
Heavily bodied linseed oil	440	108	40	2.0
Water-based exterior paint	300	95	4	0.5
Water-based exterior paint	425	105	4	0.5