



Designation: D1316 – 06 (Reapproved 2011)

Standard Test Method for Fineness of Grind of Printing Inks By the NPIRI Grindometer¹

This standard is issued under the fixed designation D1316; 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 describes the procedure for determining the fineness of grind of printing inks using a NPIRI Grindometer. It evaluates the size of the largest particles in a finished dispersion but not average particle size or concentration of sizes.

1.2 This test method covers both manual and automatic drawdowns using an A1 scraper.

1.3 This test method is applicable to any dispersion that is fine enough to fall within the 0–25 μm range of the specified grind gauge. With a minor variation in procedure, it is applicable to both paste (nonvolatile) and liquid (volatile) inks.

NOTE 1—The 0–25 μm gauge specified in this test method is similar in principle to the 0–100 μm Hegman gauge described in Test Method D1210 and the various gauges described in ISO 1524:2000. Sieve analysis for concentration of particles above 45 μm is covered in Test Method D2067.

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 and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards:²

D1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gauge

D2067 Test Method for Coarse Particles in Printing Ink Dispersions

D6846 Practice for Preparing Prints of Paste Printing Inks with a Printing Gauge

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

¹This 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 D01.56 on Printing Inks.

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²For 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.

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 ISO Standards:³

ISO 1524:2000 Paints, varnishes and printing inks — Determination of fineness of grind

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *fineness of grind, n*—a measure of the size and prevalence of oversize particles in a printing ink dispersion.

3.1.2 *NPIRI grind unit (gu), n*—the distance equal to 2.5 μm or 0.1 mils on a grind gauge.

3.1.3 *scratch, n*—a depression at least 10 mm in length in the surface of a grind gauge drawdown.

3.1.3.1 *Discussion*—A scratch develops when a particle (or agglomerate) is trapped between the blade and the bottom of the path and is drawn along by the blade.

3.1.4 *speckle, n*—protuberance of particles above the surface of a grind gauge drawdown.

3.1.4.1 *Discussion*—Speckles occur at gauge depths greater than those at which scratches occur and are caused by oversize particles that are not hard enough or of the proper size to produce scratches.

4. Summary of Test Method

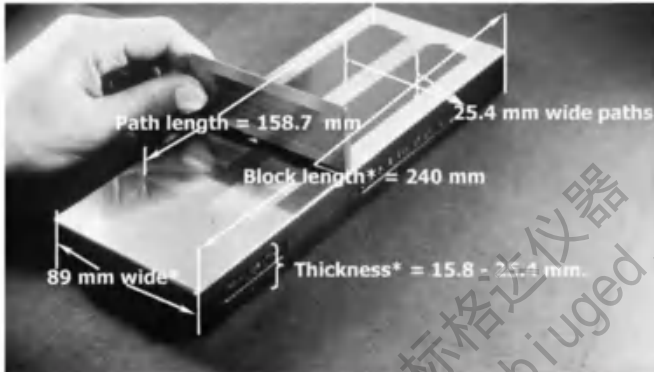
4.1 This test method utilizes a NPIRI Grindometer having two precision machined grooves each 25.4 mm (1 in.) wide and with a 0–25 μm (0–1 mil) taper. The test specimen is drawn down the paths slowly if a nonvolatile (paste) ink, briskly if a volatile (liquid) ink. The drawdowns are examined for the scale readings at which four and ten scratches appear and at which a preponderance of speckles disappear. A single determination of fineness of grind requires readings from four paths and the computation of an arithmetical mean.

5. Significance and Use

5.1 Oversize particles in a printing ink may damage a printing plate, plug a cell, clog a nozzle and adversely affect the

³ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

*A Summary of Changes section appears at the end of this standard



Note—The operator has stopped this drawdown to show the 90° angle of scraper to NPIRI Grindometer and that there is no ink on shoulders, indicating proper pressure. Note, thickness, width of block, and overall block length are non-critical dimensions.

FIG. 1 The NPIRI Grindometer is Shown with Machined Dimensions

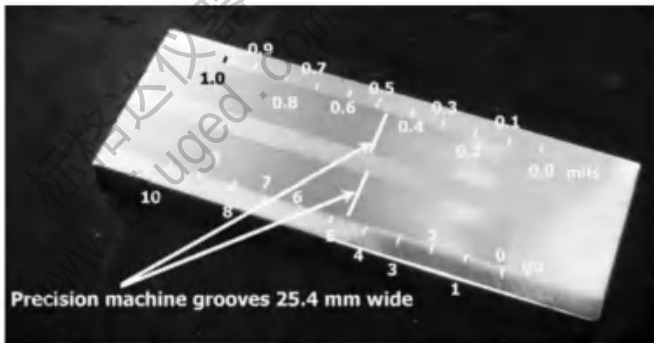


FIG. 2 The NPIRI Grindometer Showing Precision Tapered Grooves with Inscribed Markings in Mils (Upper Groove) and NPIRI Grind Units = GU (Lower Groove)

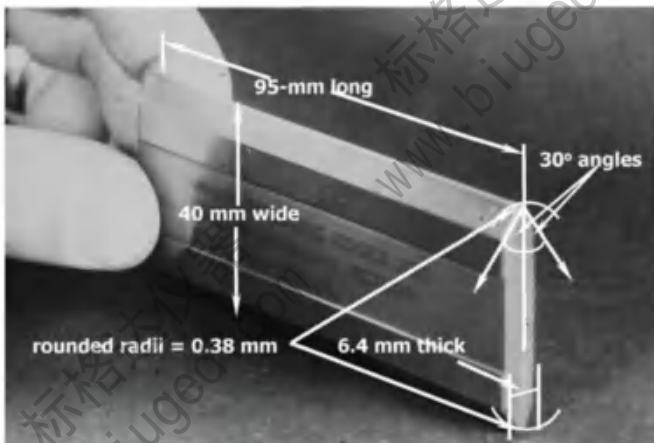


FIG. 3 A Double Edged Blade (A1 Scraper) Conforming to ASTM Test Method D1210 is Shown with Machined Specifications

appearance of printed ink films. Fineness of grind measurements are useful for deciding when to stop the dispersion process and for determining if the test material meets specifications as agreed upon between the supplier and the customer.

6. Apparatus

6.1 *NPIRI Grindometer*,⁴ consisting of a block of hardened steel 25.4 mm in thickness,⁵ 89 mm in width and 240 mm in length: see Fig. 1. The top surface of the block is precision machined so as to contain two paths, each 25.4 mm in width, 165 mm in length, and tapered uniformly in depth lengthwise from 25.4 μm (1 mil) to zero depth as shown in Fig. 2. Depth markings are inscribed on the shoulders at each 2.5 μm (0.1 mil) change in taper. Scale inscriptions and the relationship among various scales are given in Table 1.

TABLE 1 Relation Among Grind Gauge Scales

NOTE 1—gu—NPIRI Grindometer unit.

NPIRI Scale, ^A gu	Depth ^B		Micrometer Scale, ^C μm	Hegman Scale ^D
	mils	μm		
0	0	0	0	8
1	0.1	2.5		
2	0.2	5	5	
3	0.3	7.5		
4	0.4	10	10	
5	0.5	12.5		7
6	0.6	15	15	
7	0.7	17.5		
8	0.8	20	20	
9	0.9	22.5		
10	1.0	25	25	6
15	1.5	38		5
20	2.0	50	50	4
25	2.5	63		3
30	3.0	75	75	2
35	3.5	88		1
40	4.0	100	100	0

^A Numbers above dashed lines are inscribed on the side or on the left shoulder of all standard NPIRI Grindometers. Numbers below dashed lines represent extended scales available on special gauges.

^B Nominal depth, not necessarily thickness of material deposited in paths of grind gauges. Path fillage is about 80 % for a high viscosity (sheet-fed offset) ink; 60 % for a low viscosity (letterpress news) ink. Path fillage is also decreased by fast drawdowns.

^C Numbers above dashed lines are inscribed at every fifth calibration line on the right shoulder of newer NPIRI Grindometers.

^D Paint Scale in Test Method D1210.

6.2 *A1 Scraper*,⁶ a double-edged blade conforming to Test Method D1210. Fig. 3 shows critical specifications.

6.3 *Ink Knife*, a small, flexible metal blade.

6.4 *Automatic Drawdown Machine (ADM-1)*,⁷ (optional) for use with paste ink dispersions only. A diagram of the unit is illustrated in Fig. 4.

⁴ The NPIRI Grindometer, developed by the National Printing Ink Research Institute, may be obtained from the Precision Gage and Tool Company, 375 Gargrave Rd., W. Carrollton, OH 45449 (<http://www.precisiongage-tool.com>).

⁵ Also available is a model 23.3 mm (0.918 in.) in thickness, which may serve as a type-high printing plate in a flat-bed press as described in Practice D6846.

⁶ A second scraper should be procured for use while the first scraper is being reconditioned or is otherwise out of commission.

⁷ The sole source of supply of the Automatic Drawdown Machine (ADM-1) known to the committee at this time is Little Joe Industries, 10 Ilene Court, Hillsborough, NJ 08844-1922. If you are aware of alternate suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

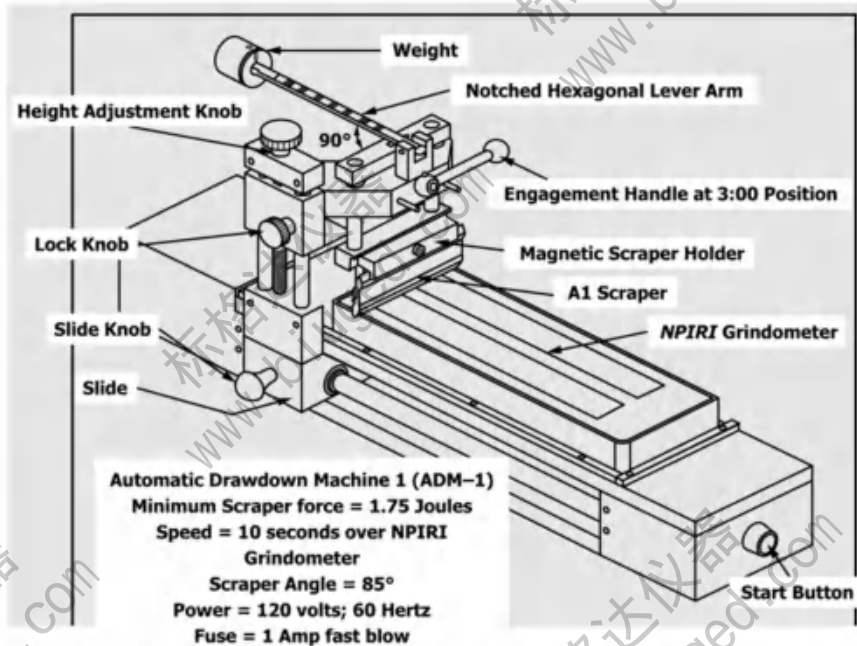


FIG. 4 An Automated Drawdown Machine (ADM-1), with Part Identification, is Shown with the NPIRI Grindometer and A1 Scraper in Place

7. Materials

7.1 *Rags or Tissues*, lint- and metal-free.

7.2 *Solvent*, naphtha or other as appropriate for the ink under test.

8. Care of Gauge and Blade

8.1 *Cleanliness*—The scraper and the block must be visually clean prior to a drawdown. Any dirt or lint present may produce a scratch and give a false reading.

8.2 *Misuse*—The Grindometer is a precision instrument and must be treated as such. Do not let any hard materials contact the gauge surface or scraper in any manner that might result in scarring or nicking. Avoid tapping or scratching with other metal. Use only soft metal-free cloths for cleanup.

8.3 *Normal Wear*—Under steady usage over an extended period of time, both scraper and block will wear but localized scraper wear is much more rapid than block wear. Periodically check the blade as follows:

8.3.1 *Method 1*—Place a small quantity of an ink across one end of a flat glass plate and make a drawdown. A uniform drawdown indicates that the particular scraper edge is in good condition. A streak of ink or a heavier film of ink at the places corresponding to the shoulders of the Grindometer is evidence of blade damage or excessive wear. Repeat the drawdown with the other edge of the blade.

8.3.2 *Method 2* (from Test Method D1210)—Face one edge of the scraper down across the bottom of the top surface of the Grindometer or other smooth level surface. Place a strong light behind the scraper and examine the contact edge; any light coming through shows that the blade edge has been damaged and is not satisfactory for use. Wear and warpage can also be

detected by rocking the blade back and forth. Repeat the procedure on the other edge of the blade.

8.4 *Rusting*—The Grindometer is made of carbon steel and is subject to rusting. Apply a coating of grease or other rust-preventative and keep covered or encased when not in use.

Warning—Do not use a gauge or blade that exhibits damage or wear (see 8.2 – 8.4). Replace or return to the manufacturer for reconditioning.

9. Sampling

9.1 Approximately 2 to 3 mL of ink sample is sufficient to fill four paths of the Grindometer. When taking samples either from a container or from a disperser, push aside the top layer and take the sample from below. This technique prevents skin or surface dust from being transferred to the gauge.

9.2 If the sample is a liquid ink, hand stir the sample vigorously for 2 min, taking care that air bubbles are not whipped in.

10. Procedure for Manual Drawdowns

10.1 Place the gauge NPIRI Grindometer on a flat, non-slippery surface so that the deep end of the grooves is farthest from the operator. Wipe clean immediately before the test. Be sure the gauge surface is dry and free of lint and wipe marks.

10.2 Using the ink knife, transfer a small quantity of ink across the deep end of both grooves (see Fig. 5) about 12.5 mm (½ in.) from the end of the block. Alternatively, different inks may be placed in the two respective paths.

10.3 Grasp the scraper in both hands and, holding in a vertical position, place it behind the ink of the gauge. Apply adequate pressure to ensure positive contact of the blade with



FIG. 5 Shown is an Ink Knife Supplying a Test Sample Across the Path Width of a NPIRI Grindometer

the surface of the gauge and draw the ink down the length of the path. Ink remaining on the shoulders is evidence of insufficient pressure.

10.3.1 *Paste Inks*—Make the drawdown with a smooth steady stroke that takes 7 to 10 s to complete.

10.3.2 *Liquid Inks*—Make the drawdown with a brisk stroke that takes 1 to 2 s to complete. When testing fluid inks, it is essential to work quickly, as partial drying of the ink specimen or the ink film can influence test results.

10.4 Set the blade on a sheet of scrap paper, and read the endpoints as prescribed in Section 12.

10.5 After reading the endpoints, clean the gauge and repeat the procedure in 10.2 – 10.4 until readings have been made on four paths per sample. If a reference standard was used in one path, alternate its position on the repeat tests.

11. Procedure for Automatic Drawdowns Using ADM-1

11.1 Place the automatic machine on a sturdy level area.

11.2 Turn the engagement handle counter clockwise to the 9 o'clock position.

11.3 Place the clean Grindometer onto the rubber pad, top plate. Wipe clean immediately before the test. Be sure the gauge surface is dry and free of lint and wipe marks.

11.4 Place the clean scraper into the notch of the scraper holder and set the appropriate weight(s) onto the ADM-1 hexagonal notched arm level. The torque selected is critical since too much will shorten life of scraper and too little will not clean the shoulders of the gauge (see Fig. 1).

Note 2—Each location or sample, or both, requires that adequate torque be applied during the automatic drawdown. This procedure is initially performed by placing the sample as described, placing the weight mid range on the fulcrum arm. If the resulting drawdown cleans the shoulders then, the operator should redo the sample on a clean gauge with the weight one notch closer to the fulcrum point or until ink appears on the shoulders, or both. Moving the weight closer to the fulcrum point decreases the torque, while placing the weight away from the fulcrum point increases the torque. The weight, size, and hexagonal notch data should be recorded with each sample.

11.5 Carefully turn the engagement handle clockwise to the 3 o'clock position. The scraper should come into contact with the Grindometer. Note the scraper angle in the specifications list of your ADM-1.

11.6 Observe the position of the hexagonal lever. It should be horizontal.

11.7 Turn the engagement handle counter clockwise back to the 9 o'clock position.

11.8 Pull the slide knob out and move the slide to the top of the ADM-1.

11.9 Using a clean ink knife, place a small portion of the sample on the top of the gauge track. Carefully place the samples approximately 12.5 mm (½ in.) from the top of both grooves. The knife should not touch the gauge.

11.10 Turn the engagement handle to the 3 o'clock position. The scraper will contact the gauge. Do not allow the engagement handle to drop quickly since it may damage the edge of the scraper or the gauge.

11.11 Press and hold the Start button until the scraper passes zero on the gauge. The ADM-1 takes about 10 s to complete the path.

11.12 Immediately remove the scraper, pull the slide knob and return the sled to its start position.

11.13 Immediately pick up the gauge to read the endpoints as prescribed in Section 12.

11.14 After recording the endpoints clean the gauge and repeat the procedure in 11.2 – 11.5 until readings have been made on four paths per sample. If a reference standard was used in one path, alternate its position on the repeat tests.

12. Reading of Endpoints and Report

12.1 Immediately after completing the drawdown, pick up the Grindometer and rotate in a light until the patterns, when viewed from the side, are clearly visible. Record endpoints within 5 to 10 s of completing the drawdown. Record the



Note—The endpoints (shown) are 7 gu for four scratches and 4.5 gu for 10 scratches greater than 1 gu (10 mm) in length.

FIG. 6 Examples of Scratch Patterns on a NPIRI Grindometer



TABLE 2 Manual Procedure 4 and 10 Scratches

4 MANUAL					
Material	Ave	sr	SR	r	R
C	2.18	0.32	2.06	0.90	5.77
B	3.77	0.61	2.39	1.71	6.69
G	5.45	0.2	0.72	0.56	2.02
F	8.77	0.42	0.54	1.18	1.51
A	9.05	0.39	0.74	1.09	2.07
E	9.77	0.22	0.28	0.62	0.78
D ^A	9.99	0.06	0.06	0.17	0.17
10 MANUAL					
Material	Ave	sr	SR	r	R
B	0.83	0.25	1.63	0.70	4.56
C	0.93	0.19	1.53	0.53	4.28
G	4.89	0.3	0.68	0.84	1.90
A	6.88	0.27	1.86	0.76	5.21
F	7.09	0.48	0.53	1.34	1.48
E	9.15	0.18	0.64	0.50	1.79
D ^A	9.95	0.11	0.11	0.31	0.31

^A These results are just provided for information. This sample (D) was outside the range of the NPIRI Grindometer scale. The values reported make both repeatability and reproducibility values unreliable.

TABLE 3 Automatic Procedure (ADM-1) 4 and 10 Scratches

4 AUTO					
Material	Ave	sr	SR	r	R
C	5.55	0.61	2.80	1.71	7.84
G	5.77	0.20	0.28	0.56	0.79
B	7.76	0.33	1.60	0.92	4.48
F	8.80	0.49	0.71	1.37	1.99
A	9.25	0.12	0.86	0.34	2.41
E	9.88	0.06	0.13	0.17	0.36
D ^A	10.00	0.00	0.00	0.00	0.00
10 AUTO					
Material	Ave	sr	SR	r	R
C	1.97	0.11	3.07	0.31	8.60
B	2.69	0.39	3.75	1.09	10.50
G	5.28	0.16	0.52	0.45	1.46
A	7.17	0.47	2.96	1.32	8.29
F	7.21	0.33	0.67	0.92	1.88
E	9.20	0.33	0.66	0.92	1.85
D ^A	9.98	0.06	0.06	0.01	0.17

^A These results are just provided for information. This sample (D) was outside the range of the NPIRI Grindometer scale. The values reported make both repeatability and reproducibility values unreliable.

TABLE 4 Pooled s and r From Round Robin

Endpoint	Repeatability Standard Deviation = s gu (μm)	Repeatability Intervals = r gu (μm)
4 Scratches Manual	0.39 (0.99)	1.08 (2.7)
10 Scratches Manual	0.30 (0.76)	0.83 (2.1)
4 Scratches Automatic	0.36 (0.91)	0.93 (2.4)
10 Scratches Automatic	0.32 (0.81)	0.84 (2.1)

following endpoints to $\frac{1}{2}$ gu (see NPIRI scale in Table 1 and Fig. 6) or to $1 \mu\text{m}$, or both.

12.1.1 The first point from the deep end at which four scratches, each at least 10 mm long, occur simultaneously. The scratches need not reach the bottom of the plate groove.

12.1.2 As in 12.1 for ten scratches.

12.1.3 The place at which speckles disappear.

12.2 Record the three types of endpoints on a total of four paths and compute the respective means.

12.3 When reporting endpoints, mean figures may be rounded to $\frac{1}{2}$ gu, or to $1 \mu\text{m}$, or both.

13. Precision and Bias⁸

13.1 Precision:

13.1.1 An interlaboratory study, initiated August 2003, (with a total of 10 participating labs) using Manual and Automatic (ADM-1) procedures of this test method was conducted in which one operator in each of seven labs used both manual and automatic (ADM-1) methods. These laboratories made two determinations, each the arithmetical mean of readings on two drawdowns, on seven samples (A – G). The results were analyzed statistically in accordance with Practice E691 and Practice E177. The complete study is on file with ASTM in Research Report RR:D01-1134.⁸

NOTE 3—The NPIRI Grindometers and A1 Scrapers used in this round robin were manufactured by Precision Gage and Tool. All available apparatus may not be suitable for this application. Apparatus considered for use in this application shall be checked for suitability in accordance with the requirements of 6.1 and 6.2.

⁸ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1134. Contact ASTM Customer Service at service@astm.org.



13.1.2 **Table 2** is the Manual Procedure only; **Table 3** is Automatic Procedure (ADM-1) only.

NOTE 4—In **Table 2** and **Table 3** the endpoint data for 4 and 10 scratches are presented separately and is arranged in increasing order. Speckles values are not being included since responses were not quantified.

13.1.3 **Table 4** is the remaining 6 repeatability standard deviations (s_r) and repeatability intervals (r) for Manual and Automatic (ADM-1) procedures. Pooling these together provides overall estimates for each procedure in **Table 4**. Pooled information is given in gu units and microns (μm).

NOTE 5—It is not feasible to specify reproducibility of this procedure. See Footnote A in **Table 2** and **Table 3**. Because of the extremely large differences in reproducibility standard deviations it is not practical to pool these values together and, therefore, they are not included in **Table 4**.

NOTE 6—The differences in reproducibility do not seem to be dependent on grind average but are somewhat random across the range of values. Large reproducibility standard deviation is generally a result of large differences in laboratory averages. For example, the SR of 2.80 with Material C Automatic 4 lines was due to laboratories averaging from a low of 2.25 to a high of 9.875. Material G, however, had averages between

5.375 and 6.0 for a reproducibility standard deviation of only 0.28. It is important for the user of this standard to recognize these possible variations.

13.1.4 NPIRI Grindometer range 0 to 10 gu (NPIRI Grindometer unit). The precision information given in **Tables 2-4** is reported in gu units. See **Table 1**.

13.2 *Bias*—Bias cannot be determined because the properties measured, 4, 10 scratches and speckles are subjectively read, and the actual grind value of the samples was not determined or confirmed.

Recommended Terminology for Terminology for Indexes

r	=	95 % repeatability limit (within a laboratory)
R	=	95 % reproducibility limit (between laboratories)
s_r	=	repeatability standard deviation (within a laboratory)
SR	=	reproducibility standard deviation (between laboratories)

14. Keywords

14.1 A1 Scraper; Automatic Drawdown Machine (ADM-1); degree of dispersion; grind gauge; NPIRI Grindometer; pigment dispersions; printing inks

SUMMARY OF CHANGES

Committee D01 has identified the location of selected changes to this standard since the last issue (D1316 – 93 (2001)) that may impact the use of this standard.

- (1) Scope statement includes an automatic procedure using an automatic drawdown machine (ADM-1) and A1 Scraper.
- (2) Addition of automatic drawdown machine (ADM-1), equipment requirements, methodology, and keywords to **1.2**, **6.4**, Section **11**, and Section **14**.
- (3) Addition of ISO 1524 to **Note 1** and Referenced Documents.
- (4) Addition of Practice **D6846** to Referenced Documents and Footnote 5.
- (5) Addition of Practice **E177** to Referenced Documents.
- (6) Addition of Discussion 3.1.3.1.
- (7) Addition of Terminology **3.1.4**.
- (8) Priority of metric system **4.1**.
- (9) Addition of last sentence to **4.1**.
- (10) Addition of **Figs. 1-6**.
- (11) Deleted **5.2** since it refers to previous research Report and previous Precision and Bias statements.
- (12) Addition of apparatus **6.4**.
- (13) Addition of Footnote 7 identifying Little Joe Industries as sole source of ADM-1.
- (14) Relocation of sentence "Immediately after making the drawdown, pick up the Grindometer and rotate" ... from 10.4 to beginning of **12.1**.
- (15) Addition of Section **11** Procedure for automatic drawdown using ADM-1.
- (16) Addition of new Precision and Bias Section **13**.
- (17) Addition of **Note 3** identifying manufacturing source of the NPIRI Grindometer and A1 Scraper used in Research Report D01 – 1134 and criteria that shall be used for alternate available apparatus.
- (18) Addition of **Note 4** explaining data arrangement of **Table 2** and **Table 3**.
- (19) Addition of **Note 5** stating poor feasibility of R and SR .
- (20) Additional Keywords Section **14**, A1 Scraper, Automatic Drawdown Machine (ADM-1).
- (21) Deletion of **Table 2** Precision Grindometer Endpoints for Roll-Milled Dispersions.
- (22) Addition of **Table 2** Manual Procedure 4 and 10 Scratches.
- (23) Addition of **Table 3** Automatic Procedure 4 and 10 Scratches.
- (24) Addition of **Table 4** Pooled s and r from Round Robin Research Report D01 – 1134.
- (25) Addition of **Note 6** explaining why Reproducibility (R) and reproducibility standard deviation (sR) are not included.
- (26) Explanation of D^A (**Table 3**) why data was not included in calculations.
- (27) Summary of Changes added.



D1316 – 06 (2011)

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