Designation: D 6702 – 01

Standard Test Method for Determining the Dynamic Wiping Efficiency of Nonwoven Fabrics Not Used in Cleanrooms[1]

This standard is issued under the fixed designation D 6702; 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 covers the quantifying of the dynamic wiping efficiency of nonwoven fabrics.

1.2 This test method applies to all nonwoven fabrics not used in cleanrooms.

NOTE 1—For dynamic wiping efficiency in cleanrooms, refer to Test Method D 6650 Standard Test Method for Determining the Dynamic Wiping Efficiency, Wet Particle Removal Ability, and Fabric Particle Contribution of Nonwoven Fabrics Used in Cleanrooms.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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 [2,3]

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[4]

D 6650 Test Method for Determining the Dynamic Wiping Efficiency, Wet Particle Removal Ability, and Fabric Particle Contribution of Nonwoven Fabrics Used in Cleanrooms

3. Terminology

3.1 *Definitions:*

3.1.1 *cleanroom*, *n*—a room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room.

3.1.1.1 *Discussion*—In addition to particles, other relevant parameters, such as temperature, humidity, and pressure, are controlled as required. The so-called Class of a cleanroom is defined in documents including, but not limited to, Federal Standard 209E as the concentration per unit volume of particles of a designated size. The various systems for such classification lie beyond the scope of this document.

3.1.2 *dynamic wiping efficiency*, *n*—in textile fabrics, the ability of a fabric to remove water, or other liquids, from a surface, usually for spill removal.

3.1.2.1 *Discussion*—The ability of a fabric to hold liquid is largely a function of the composition and consturction of the fabric. A naturally sorptive fabric made of or with hydrophilic components will ABSORB liquid (typically water), while those made of hydrophobic materials will ADSORB liquid (typically water) between the interstices of the fibers composing the fabric. In many cases, both absorption and adsorption take place.

3.2 For definitions of terms used in this test method refer to Terminology D 123.

4. Summary of Test Method

4.1 A quarter-folded fabric swatch is clipped to the underside of a 1-kg sled and pulled through a known challenge of liquid, usually water, placed on a flat surface directly in front of a wiper fabric and sled. The percent of liquid removed from the surface is determined gravimetrically as the dynamic wiping efficiency.

5. Significance and Use

5.1 This test method can be used for acceptance testing of commercial shipments but comparisons should be made with caution because information on estimates of between-laboratory precision is limited as noted in the precision and bias section of this test method.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, samples used for such comparative tests should be as homogeneous as possible, drawn from the

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[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.64 on Nonwovens.

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[2] Oathout, J. M., "Determining the Dynamic Efficiency of Cleanroom Wipers for Removal of Liquids and Particles from Surfaces," *Journal of the IEST*, 62 (3), 17–26, May/June 1999.

[3] "Evaluating Wiping Materials Used in Cleanrooms and Other Controlled Environments," IEST-RP-CC004.2, Institute of Environmental Science and Technology, 940 East Northeast Highway, Mount Prospect, IL 60056 (1992).

[4] *Annual Book of ASTM Standards*, Vol 07.01.

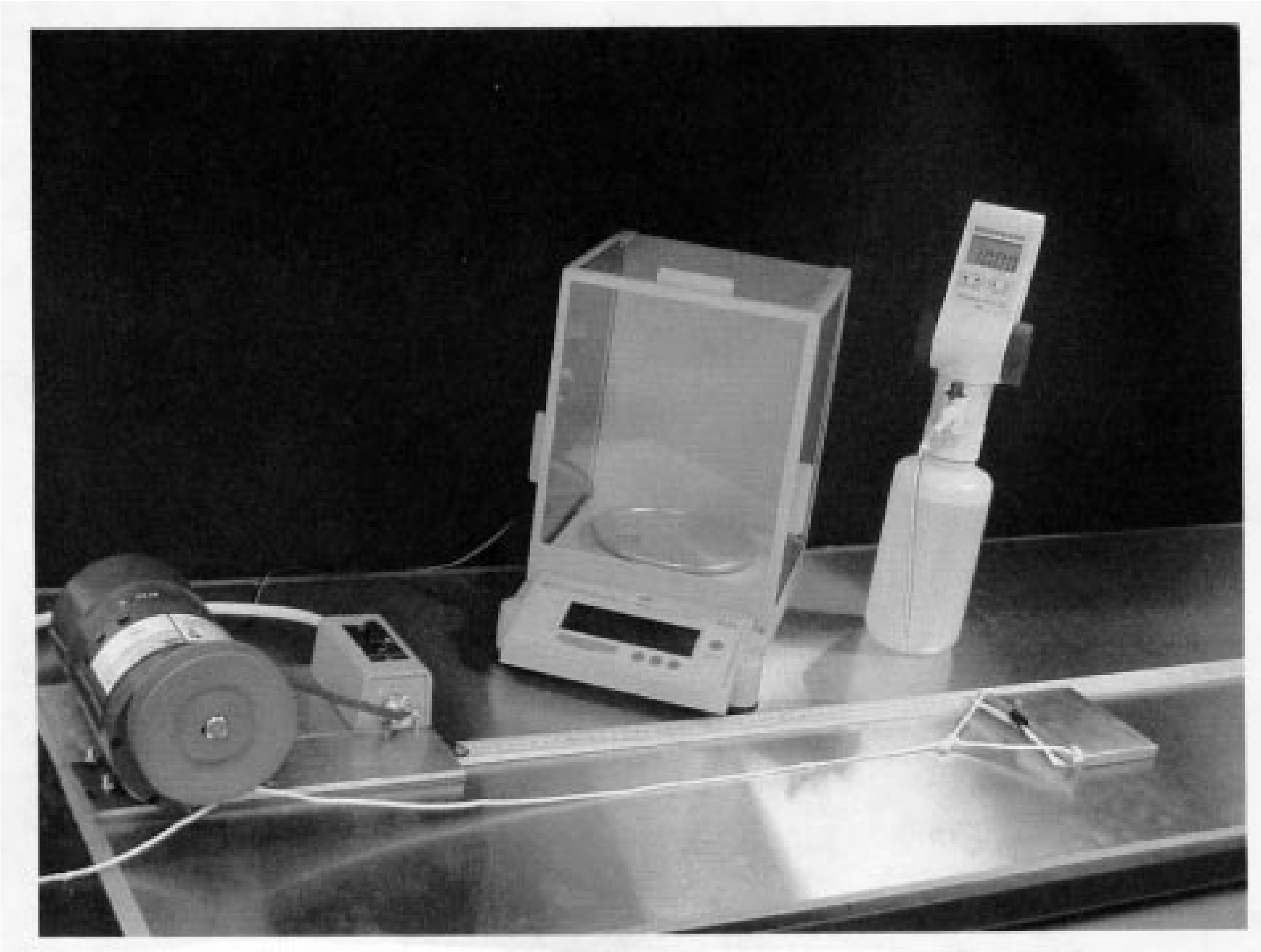


FIG. 1 Illustration of Dynamic Wiping Efficiency Apparatus

same lot of material as the samples that resulted in disparate results during initial testing, and randomly assigned in equal numbers to each laboratory. Other fabrics with established test values may also be used for these comparative tests. The test results from the laboratories involved should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 This test method depends on the ability to accurately place a known mass/volume of liquid on the surface, so that an accurate mass of liquid adsorbed may be determined.

5.3 This test method is useful to select fabrics with superior cleaning and drying properties that can minimize the costs for spill removal. It can also be used to research fabrics for improved spill removal and for production control.

6. Apparatus and Materials

6.1 *Dynamic Wiping Efficiency Test Apparatus*, consisting of a polyester string attached to two stainless steel screws on a stainless steel sled (6.1.1), forming a yoke, and with a second polyester string, approximately 1.5-m (5 ft) long having one end of attached at the midpoint of the yoke and the other end attached to a motor (6.1.2) that provides a sled pull rate of 25 cm/s (10 in./s). (See Fig. 1).

6.1.1 *Sled*, # 304 stainless steel, 1 kg ± 10g, 117 × 117 mm base, 9.53 mm thick (4.63 by 4.63 in. base, 0.375 in. thick); a curved leading edge, 13 mm (0.50 in.) radius, on the base of the sled forms a lip to which the quarter-folded sample is attached using a spring-loaded clip. Two stainless steel screws are affixed to either outboard edge of the sled in the leading curved edge. (See Fig. 2).

6.1.2 *Motor*, 60 Hz. equipped with a 25 cm (9.84 in.) circumference sheave used as a capstan device to pull the sled at a constant and uniform speed of 25 cm/s (10 in./s).

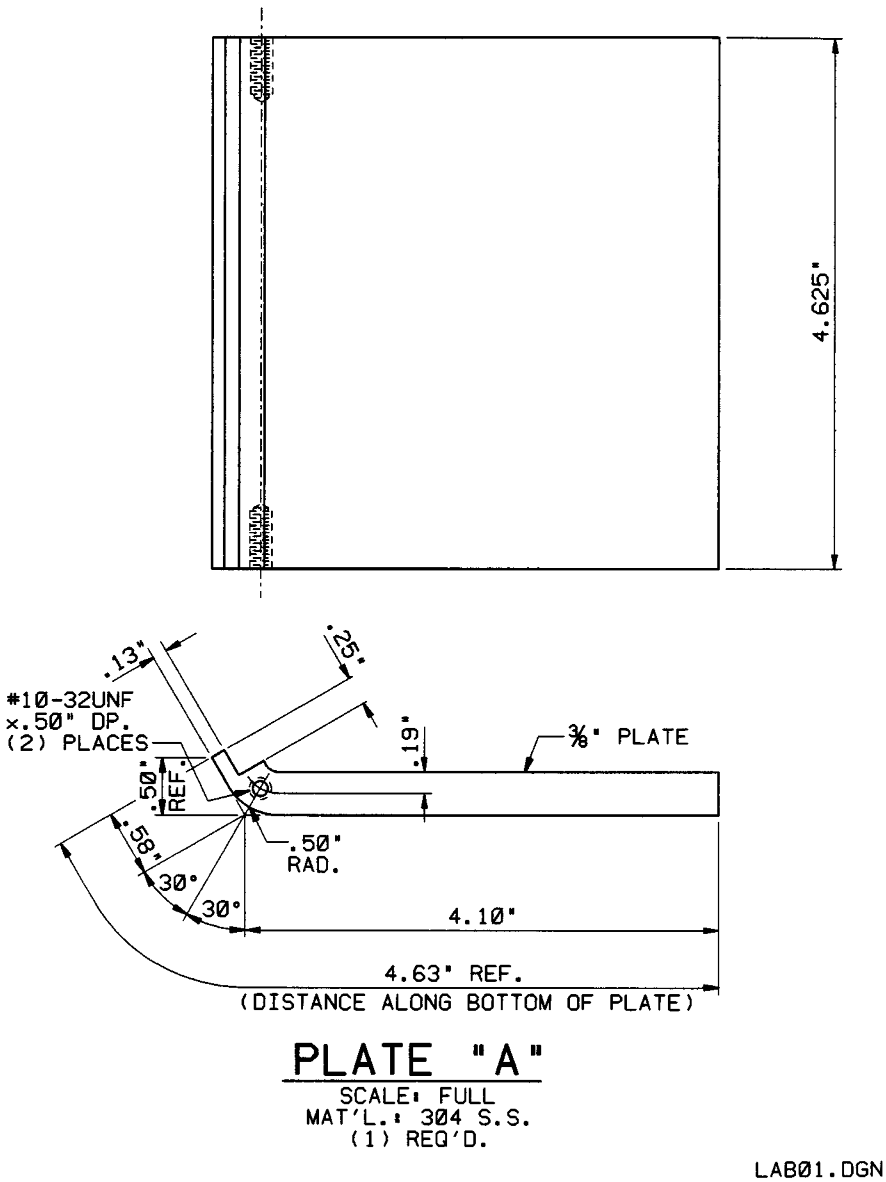
6.2 *Balance*, top loading, shielded, 0.01 g readability.

6.3 *Metal Plate*, No. 304, 18 gauge stainless steel, Polish #3 (Brush finish), 61 cm (2 ft) × 122 cm (4 ft).

6.4 *Dispenser*, digital bottletop burette, for reproducible and accurate delivery of liquid volumes, Brinkmann Bottletop Buret, Model 25, or equivalent.

6.5 *Liquid*, usually water at least distilled grade, or other liquid when specified.

6.6 *Tray*, or other container, suitable for wetting out a 229 mm (9.00 in.) square specimen to determine intrinsic soptive



NOTE—For SI units in millimeters, multiply inches by 25.4.

FIG. 2 Drawing of Sled

capacity (See Annex A1).

7. Sampling and Test Specimens

7.1 *Primary Sampling Unit*—Consider rolls, bolts, or pre-packaged pieces of textile fabric to be the primary sampling unit, as applicable.

7.2 *Laboratory Sampling Unit*—As a laboratory sampling unit, take from the primary sampling unit at least a one full-width piece of fabric that is 1 m (1 yd) in length along the machine direction, after removing a first 1 m (1 yd) length.

7.2.1 For primary sampling units having narrow widths or short lengths, use a sufficient number of pieces to prepare eight test specimens to the size described in 7.3.

7.3 *Test Specimen Size*—From each laboratory sampling unit, cut eight square test specimens 229 by 229 mm (9.00 by 9.00 in.); four specimens for the 10 mL challenge test and four specimens for the 50 % capacity challenge test. Specimen preparation need not be carried out in the standard atmosphere for testing. Label to maintain specimen identity.

7.3.1 Primary sampling units may consist of pre-packaged wiping material that are nominally 229 by 229 mm (9.00 by 9.00 in.) material squares. In those cases, use the entire square, quarter-folded, as the test specimen.

7.4 *Test Specimen Selection*—Select test specimens as follows:

7.4.1 Cut specimens representing a broad distribution diagonally across the width of the laboratory sampling unit.

7.4.2 Take no specimens closer than 25 mm (1.0 in.) from the machine direction edge, except as noted in 7.3.1.

7.4.3 Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, grease, etc. on the specimens when handling.

8. Conditioning

8.1 No conditioning is required unless otherwise specified in a material specification or contract order.

9. Preparation of Test Apparatus and Calibration

9.1 Ensure the sled pulling speed is as specified.

9.2 Verify that the balance is within calibration.

9.3 Separate challenges of 10 mL and the volume representing 50 % of the ply's capacity are required.

9.3.1 If the intrinsic sorptive capaci-ty, A_i [mL/g], of a fabric is not already known, determine it on a separate ply of the material as directed in Annex A1. From the calculated A_i and the measured mass of each fabric, calculate the per-ply capacity A_{ip}[mL] for each fabric. This quantity is needed in order to calculate to volume representing a 50 % capacity challenge [$0.5A_{ip}$].

9.4 Verify calibration of the burette dispenser. For example: For a burette delivery of 10.00 mL of water, the water at 25°C has a density of 0.997 g/mL that must have a mass of 9.97 g.

10. Procedure

10.1 Handle the test specimens carefully to avoid altering the natural state of the material.

10.2 Quarter-fold a test specimen, place on the balance and record its dry mass, M_d, to the nearest 0.01 g.

10.3 Clip the quarter-folded test specimen to the sled so that the single convex fold is at the leading edge without the test specimen extending beyond the footprint of the sled.

10.4 Position the sled at one end of the stainless steel plate with the leading edge perpendicular to the axis of the long dimension of the plate.

10.5 Using the dispenser, place a 10.00 ± 0.02 mL volumetric challenge of liquid, v_c, onto the plate at a point 1-2 cm (0.5-0.75 in.) in front of the leading edge of the sled.

10.6 Loosely wrap the free end of the sled pull-string around the capstan-sheave on the motor. Using the string, apply tension that starts the motor to move the sled at a constant rate of speed of 25 cm/s (10 in./s) along the long axis of the steel plate for a distance of 1 m (40 in.). Release the tension on the string around the sheave to stop the sled motion.

10.7 At the end of 1 m (40 in.) travel, with the sled turned fabric-side-up, remove the folded test specimen from the sled, place on the balance and record its wetted mass, m_w, to the nearest 0.01 g.

10.8 Continue as directed in 10.1-10.7 until four specimens have been tested using a 10 mL challenge for each laboratory sampling unit.

10.9 Using the remaining four test specimens, test each as directed in 10.1-10.7 using a 50 % capacity challenge for each laboratory sampling unit.

11. Calculations

11.1 Calculate the volume of liquid sorbed for individual specimens to the nearest 0.01 mL using Eq 1.

$$v_s = \frac{(m_w - m_d)}{D_w} \tag{1}$$

where:

v_s = volume of liquid sorbed, mL,
m_w = mass of the test specimen after wetting, g (from 10.7),
m_d = mass of the test specimen before wetting, g (from 10.2), and
D_w = 0.997 g/mL (density of water at 25°C).

11.1.1 If liquids other than water are used, substitute the appropriate density in Eq 1.

11.2 Calculate the Dynamic Wiping Efficiency of individual specimens for both the 10 mL challenge and the 50 % capacity challenge to the nearest 0.1 % using Eq 2.

$$DWE = \frac{100\, v_s}{v_c} \tag{2}$$

where:

DWE = Dynamic Wiping Efficiency, %,

TABLE 1 Physical Characteristics Of The Ten Wiping Materials In This Study

Wiper Material	Basis Weight[A] [g/m^2]	Construction and Composition
		Nonwoven Fabrics
1	90.9	woodpulp, binder; modified papermaking process; double re-creped; white; quarter folded individual plies, 33 × 33 cm (12.9 × 13 in.)
2	66.6	55 % woodpulp/45 % polyester; hydroentangled, blue, non-creped, 36 × 43 cm (14 × 17 in.)
3	80.0	55 % woodpulp, 45 % polyester; hydroentangled white, creped and embossed with logo, 30 × 34 cm (12 × 13.25 in.), quarter folded
4	109	38/34/28 % nylon/woodpulp/polyester; stitchbonded bulked, white, individual sheets 46 × 35 cm (17.9 × 13.7 in.)
5	71.7	70 % rayon/30 % polyester, 8 mesh, hydroentangled yellow, binder and surfactant, 21 × 19 cm, (8.14 × 7.7 in.) quarter folded (42 × 38 cm unfolded)
6	37.8	100 % polyester, surfactant treated, hydroentangled, white, individual plies, 24 × 23 cm (9.2 × 8.9 in.)
		Knitted Fabrics (Included for comparison only)
7	150	100 % polyester knit, cleanroom laundered, sealed edge knit, white, individual plies, 21 × 22 cm (8.3 × 8.7 in.)
8	153	polyester; knitted; white; cleanroom laundered individual plies, 22 × 22 cm (8.7 × 8.7 in.)
		Woven Fabrics (Included for comparison only)
9	170	cotton; woven; white, individual plies, 21 × 22 cm (8.6 × 8.4 in.)
		Meltblown (Included for comparison only)
10	71.0	polypropylene, surfactant; meltblown; thermally bonded to depict woven pattern; blue; perforated sheets 30 cm × 43 cm (11.8 × 16.9 in.)

[A] Average basis weight (mass per unit area) of the plies tested.

v_s = volume of liquid sorbed, mL (from 11.1), and
v_c = volume of the liquid challenge, mL.

11.3 Calculate the average Dynamic Wiping Efficiency for both the 10 mL challenge and the 50 % capacity challenge to the nearest 0.1 % for the laboratory sample and for the lot.

11.4 Calculate the Standard Deviation, Coefficient of Variation as applicable.

12. Report

12.1 Report that the Dynamic Wiping Efficiency was determined as directed in Test Method D 6650. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information for the laboratory-sampling unit and for the lot as applicable to a material specification or contract order.

12.2.1 Dynamic wiping efficiency for 10 mL challenge.

12.2.2 Dynamic wiping efficiency for 50 % capacity challenge.

12.2.3 When calculated, the standard deviation or the coefficient of variation.

13. Precision and Bias

13.1 *Summary*—Limited information from one laboratory is shown in Tables 1-4. These tables are constructed to illustrate what one laboratory found when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of material. For this laboratory, in comparing two averages for textile fabrics, the critical differences are not expected to exceed values shown in Table 4 in 95 out of 100 cases when the number of tests is four. Differences for other fabrics and other laboratories may be larger or smaller.

13.2 *Single-laboratory Test Data*—A single-laboratory test was run in 1999 in which randomly-drawn samples of ten fabric materials were tested. One operator in the laboratory tested six specimens from each material using both a 10 mL challenge and a 50 % capacity challenge as directed in this test method. The test specimens were tested over several days. The ten fabric types are described in Table 1.

TABLE 2 Average Dynamic Wiping Efficiency for 10 mL Challenge

Fabric Number	Capacity/ply [mL]	Challenge [% of Cap.]	DWE [%]	σ_{n-1}
1	22.97	44	93.6	2.56
2	13.85	72	92.1	2.13
3	17.30	58	98.2	0.83
4	22.73	44	98.6	0.40
5	23.62	42	97.1	0.35
6	10.85	92	94.0	1.01
7	12.71	79	91.3	1.23
8	22.83	44	95.3	3.17
9	12.40	81	92.8	1.92
10	19.76	51	87.4	5.64

TABLE 3 Average Dynamic Wiping Efficiency for Challenge of 50 % Capacity

Fabric Number	Capacity/ply [mL]	Challenge for ~50 % Cap. [mL]	Pickup [mL]	DWE [%]	σ_{n-1}
1	22.97	11.46	10.48	91.4	2.14
2	13.85	6.92	6.82	98.5	0.61
3	17.30	8.64	8.51	98.4	0.64
4	22.73	11.34	11.18	98.6	0.49
5	23.62	11.83	11.50	97.2	0.33
6	10.85	5.43	5.08	93.5	0.77
7	12.71	6.35	5.77	90.8	2.23
8	22.83	11.41	10.73	94.1	1.34
9	12.40	6.20	6.06	97.7	0.27
10	19.76	9.86	8.10	82.1	6.14

TABLE 4 Maximum Critical Differences When Comparing Averages, For N Equals 4[A] (Single-Operator Precision) Dynamic Wiping Efficiency (DWE), %

Dynamic Wiping Efficiency (DWE), % For Material as Noted	10 mL Challenge As Standard Deviation	50 % Capacity Challenge As Standard Deviation
1	2.77	3.31
2	0.79	2.76
3	0.83	1.08
4	0.64	0.51
5	0.42	0.45
6	1.62	1.30
7	2.89	1.59
8	1.73	4.10
9	0.35	2.48
10	7.93	7.29

[A] The critical differences were calculated using t = 1.960, which is based on infinite degrees of freedom.

13.3 *Precision*—Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on specimens taken from a lot of material of the type being evaluated so as to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories. (See 5.1) Interlaboratory testing will continue to provide between-laboratory precision statements.

13.4 *Bias*—The procedure of this test method produces a test value that can be defined only in terms of a test method. There is no independent, referee method by which bias may be determined. This test method has no known bias.

14. Keywords

14.1 dynamic wiping efficiency; liquid removal; nonwoven fabrics; wipe-dry

ANNEX

(Mandatory Information)

A1. ESTABLISHING INTRINSIC SORPTIVE CAPACITY OF A FABRIC

A1.1 The test for establishing intrinsic sorptive capacity of a wiper fabric should be conducted in the test room environment. It is performed by saturating a known area of the wiper fabric with a selected liquid and then calculating the volume sorbed per unit mass and per unit area as directed in A1.2-A1.9.

A1.2 Determine to three significant figures the mass and area of square fabric swatch of the same material to be tested having the same dimension as the test specimen.

A1.3 Place the specimen flat in a tray containing the selected liquid.

A1.3.1 The depth of the liquid should be such that the specimen is completely submerged.

A1.4 Allow ample time for the wiper material to sorb as much liquid as possible (usually no more than 30 s). If necessary, use physical persuasion to coax the wiper fabric to sorb to its capacity.

A1.5 After sorption is complete, grasp two adjacent corners of the specimen and remove it from the tray.

A1.6 Suspend the specimen at an angle to the horizontal, allowing the excess liquid to drip into the tray.

A1.6.1 The angle should be steep enough to facilitate dripping but not so steep that pleating of the fabric occurs. The wiper should not be stretched or otherwise dimensionally deformed as it is dripping.

A1.7 After 60 seconds, determine the mass of the wetted wiper to three significant figures.

A1.8 Repeat steps A1.3-A1.7 twice, using the same specimen.

A1.9 Average the three values for the mass of the wetted wiper fabric and calculate the sorbency as follows:

A1.9.1 Calculate sorbency per unit mass of wiper fabric (intrinsic sorbency) using Eq A1.1.

$$A_i = \frac{(m_{ww} - m_w)}{(m_w \times d_0)} \quad \text{(A1.1)}$$

where:

A_i = (intrinsic sorbency) is the volume of liquid sorbed per unit mass of the wiper fabric (mL/g),
m_{ww} = the mass of the wiper fabric wetted with the liquid (g),
m_w = the mass of the dry wiper fabric, g, and
d_0 = the density of the liquid (g/mL).

A1.9.2 Calculate the sorbency per unit area of wiper fabric (extrinsic sorbency) using Eq A1.2.

$$A_e = \frac{10^6\,(m_{ww} - m_w)}{(d_0 \times l_w \times w_w)} \quad \text{(A1.2)}$$

where:

A_e = (extrinsic sorbency) is the volume of liquid sorbed per Unit area of wiper (mL/m^2),
m_{ww} = the mass of the wiper fabric wetted, g,
m_w = the mass of the dry wiper fabric, g,
d_0 = the density of the liquid (g/mL),
l_w = the length of the wiper fabric (mm), and
w_w = the width of the wiper fabric (mm).

A1.9.2.1 Eq A1.2 can be seen to be equivalent to Eq A1.3.

$$A_e = A_i \times b_w = \left[\frac{(m_{ww} - m_w)}{(m_w \times d_0)}\right] \times b_w \quad \text{(A1.3)}$$

where:

b_w = the basis weight (mass per unit area) of the wiper fabric (g/m^2).