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An American National Standard

Standard Test Method for Short-Term Liquid Sorption Into Paper (Bristow Test)[1]

This standard is issued under the fixed designation D 5455; 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 measures the amount of test fluid absorbed onto the surface of a paper specimen under specified test conditions.

1.2 The conditions required in this test method specify reagent water as the absorbed test fluid, and a calculated time available for test fluid absorption of 1.6 s.

1.3 This test method may also be used for the measurement of solution absorption of liquids other than water having viscosities up to 100 millipascal seconds, including but not limited to inks and other water or solvent-based fluids, for surfaces other than paper, and for calculated time periods available for fluid absorption ranging from about 0.01 to about 4.0 s, or any combination of these variables, upon prior agreement of those involved.

1.4 Further information regarding the use of this test method under conditions other than the standard ones in accordance with 1.2 are included in Appendix X1.

1.5 *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]

D 528 Test Method for Machine Direction of Paper and Paperboard

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, and Related Product

D 685 Practice for Conditioning Paper and Paper Products for Testing

D 1193 Specification for Reagent Water

D 1968 Terminology Relating to Paper and Paper Products

D 5039 Test Methods for Identification of Wire Side of Paper

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For definitions of terms used in this Test Method, refer to Terminology D 1968 or *Dictionary of Paper*[3]

4. Summary of Test Method

4.1 A test specimen of defined dimensions is affixed to the smooth rim of a wheel free to rotate at a defined constant speed in contact with a stationary test fluid applicator pressing against the test specimen with a defined pressure. The test fluid applicator consists of a test solution storage compartment affixed above a 1 by 15-mm test fluid delivery slot, the slot being positioned so that the long dimension is perpendicular to the direction of rotation of the rim of the wheel, and parallel to the wheel axis. A defined quantity of test fluid is placed, through the fluid reservoir, onto the fluid delivery slot. With the wheel with the test specimen affixed rotating at constant speed, the test solution applicator is brought into contact with the rotating test specimen and held in place under defined pressure. The test fluid is transferred from the test solution applicator onto the test specimen in a band whose width, controlled by the applicator slot width, is approximately 15 mm, and whose length is a function of the sorptive characteristics of the test fluid interaction with the test specimen under the defined test conditions. The amount of liquid sorbed per unit area of test specimen is calculated from the volume of test fluid originally placed in the applicator, and the average width and length of the band created on the test specimen by the transferred test fluid. The time available for liquid sorption is calculated from the volume of test fluid originally placed in the applicator and the applicator geometry.

5. Significance and Use

5.1 The Bristow test provides a measure of the short-term sorption of water or other liquids by paper. The U.S. Postal Service has used this test method to predict the drying times of bar codes sprayed onto envelopes by inkjet. The Bristow test is

[1] This test method is under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

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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.

[3] Formerly published by American Paper and Pulp Assoc. (currently API), New York, NY.

also used to measure ink sorption by paper for a variety of printing purposes. The particular significance of this test method is its ability to characterize the sorptive properties of a paper or paper product surface independent of the thickness or bulk of the material under test.

6. Apparatus

6.1 The Bristow device consists of a stationary applicator, an applicator support fixture, and a Bristow wheel free to move about its own axis at a constant speed.

6.1.1 The Bristow device wheel used in this test method is described as follows:

6.1.1.1 A wheel fabricated of aluminum, 1.0 m in circumference and 25 mm wide.

6.1.1.2 A means to support the wheel so that it is free to rotate unencumbered about its own axis with its axis parallel to the laboratory bench surface or floor.

6.1.1.3 A means of rotating the wheel about its own axis at a constant circumference speed of 7.50 cm/min (1.25 mm/s). The Bristow wheel speed can be calculated in revolutions per minute, if desired, by dividing the circumference speed (7.5 cm/min) by the circumference (100. cm); in that case the rotational speed may be stated as 0.075 revolutions/min. It is the circumference speed that is critical to the use of the Bristow wheel, and that is the critical parameter specified in this test method.

6.1.1.4 Equipment to perform the Bristow test is manufactured with wheels of differing circumference and width from that stated in 6.1.1.1, and with the capability to be operated at a constant speed of from 3.0 to 1500 cm/min for use with a variety of different test fluids, as described in Appendix X1. The dimensions and speed stated in 6.1.1.1 and 6.1.1.3 are standard for this test method, and any deviations from the conditions stated therein must be included in the report.

6.1.2 The Bristow device liquid applicator is described as follows:

6.1.2.1 A rectangular base made of nickel-plated or chrome-plated brass having dimensions of 3.0 ± 0.2 mm and 17.3 ± 0.4 mm, centered within which is a smaller rectangular slot of dimensions 1.00 ± 0.04 mm by 15.0 ± 0.4 mm. With the slot properly positioned, the applicator will have a leading edge 1.0 mm wide, a slot 1.00 mm wide, and a trailing edge 1.0 mm wide, the slot positioned centrally across the 17.3-mm width of the applicator such that a land area of approximately 1.15 mm is present beyond the ends of the slot on each side of the slot. The dimensions of the Bristow device test fluid applicator itself, the dimensions of the slot, and the positioning of the slot within the applicator are all quite important, and the pressure required in 6.1.2.3 is achieved at the stated applicator total measured weight only when the applicator has the dimensions specified here. Likewise, the calculation for time available for fluid sorption (see 11.5) is based on adherence to the dimensions specified here.

6.1.2.2 An applicator fluid reservoir is affixed above the rectangular base whose interior walls rise vertically from the outer edges of the slot to a height of about 3 mm, and then flare outward to provide a convenient guide or volume for filling purposes. See Fig. 1.

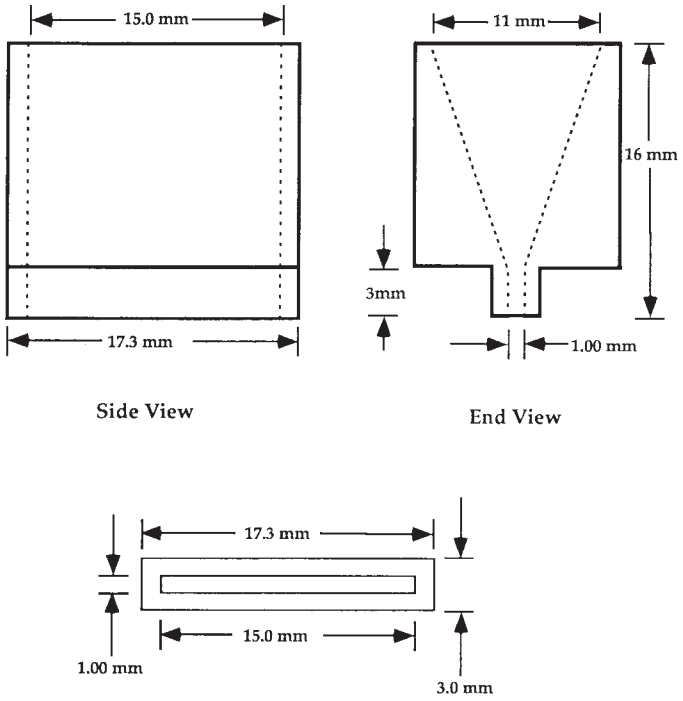

FIG. 1 Liquid Applicator

6.1.2.3 The pressure exerted by the contacting land area of the liquid applicator when the contacting land area is in contact with the specimen on the wheel must be about 0.1 ± 0.01 MPa. This is achieved for purposes of this test method by adding mass to the applicator assembly of dimensions conforming to 6.1.2.1 to a total measured weight of 400 g.

6.1.2.4 The side of the rectangular base that will be in contact with the test specimen affixed to the Bristow wheel must be smooth. If it becomes scratched or otherwise flawed, as evidenced by streaks in the band of test fluid transferred to the test specimen during a test, it must be reground following the advice of the manufacturer. The total weight must be readjusted to 400 g following regrinding, if necessary.

6.1.3 Support fixture for the test solution applicator:

6.1.3.1 Several designs are in use. The important feature is that the fixture must maintain the test fluid applicator in a constant position relative to the rotating wheel in such a manner that the long (15 mm) dimension of the applicator slot is parallel with the axis of rotation of the wheel and centered over its 25-mm width (that is, perpendicular to the circumference of the wheel and centered over the test specimen affixed to that rim) and free to exert the total mass of the applicator applying the pressure specified in 6.1.2.3 through the land area contacting the wheel.

6.1.4 Equipment conforming to the requirements of 6.1 and subsections is commercially available from several sources. It may be necessary to specify specific wheel circumference and speed required for this test method, as variations, stated in 6.1.1.3, are also available.

6.2 *Rule*, calibrated in millimetres.

6.3 *Magnifying Glass*, a simple 5 or 10×, for use in accurately estimating measurements made with the rule.

6.4 *Fluid Measuring Device*—A calibrated pipet or syringe capable of delivering a volume of test fluid of 50.0 ± 0.5 µL.

6.5 A quantity of fine monofilament polyester line, for clearing the applicator of bubbles. *In no case should a metal wire be used in place of the polyester*, as metal wire can damage the applicator base or slot, or both, particularly if left in place by accident when the applicator is lowered onto the test specimen.

7. Reagents

7.1 The test fluid required for use in this test method is reagent water. Any type reagent water, I through IV, in accordance with Specification D 1193 is suitable. A small quantity of water-soluble dye must be added to the reagent water to aid in visualization and measurement of the band of test fluid transferred to the test specimen. In this case, however, the added dye must not change the pH or surface tension of the reagent water test fluid from that which it would have in the absence of the dye.

NOTE 1—The surface tension of reagent water is generally considered to be about 70 dynes/cm. The pH of reagent water is recorded as 5.0 to 8.0 for Type IV in Specification D 1193, while that for Types I, II, and III is undefined because these types of distilled water do not contain constituents in sufficient quantity to alter the pH. In common practice, pH in the range from 5.0 to 8.0 and a surface tension of 65 dynes/cm or greater, for a solution of reagent water, Types I through IV, and a dye of choice, will comply with this test method. Some dyes contain quantities of surfactant materials that, if present in the test fluid, might significantly alter the results measured in this test method.

7.2 Other common test fluids may be used to perform the Bristow test when agreed upon between the parties involved in the testing, including alcohol, and inks containing water, alcohol, or surfactants, or combination thereof. Test fluids other than reagent water do not comply with this test method, and must be reported as a deviation in the report.

7.3 Corrosive liquids must not be used for this test method, as they attack the applicator slot, resulting in future results which may be erroneous or non-reproducible, or both.

8. Sampling and Test Specimens

8.1 *Sampling*:

8.1.1 *Acceptance Sampling*—Acceptance sampling must be in accordance with Practice D 585.

8.1.2 *Sampling for Other Purposes*—The sampling and number of test specimens depends upon the purpose of the testing. Practice E 122 is recommended.

8.2 *Test Specimens*:

8.2.1 Determine and mark the machine direction of each test unit following Method D 528.

8.2.2 Determine and mark the felt and wire sides of each test unit, if applicable, following Methods D 5039. Where the terms felt and wire side do not apply, assign arbitrary designations such as “top” and “bottom” to the principle surfaces of the test unit, based on the side which is intended to be contacted with ink or other fluid in the end-use application.

8.2.3 Cut at least two test specimens from each test unit. In the absence of prior information regarding the behavior of the material being tested under the standard conditions specified, a test specimen 1.0 m in length in the machine direction and 24 mm in width should be cut. For samples known to produce a test fluid band shorter than 1.0 m, shorter specimen lengths must be used, however the length of the specimen must always be greater than the length of the test fluid band produced under the conditions of this test method. One test specimen will be tested with the “top” or wire side in contact with the applicator and one test specimen will be tested with the “bottom” or felt side in contact with the applicator.

8.2.4 The test specimen requirements stated in 8.2.3 apply when the standard 1.0-m wheel (see 6.1.1.1) is used. If users of this test method agree to use a different circumference wheel, this is a deviation from this test method, and must be stated in the report. A test specimen size other than that required in 8.2.3 may be required is a wheel of different (particularly smaller) circumference is used. A different wheel circumference will require a change in wheel speed (revolutions per minute) to maintain the circumference speed required in 6.1.1.3.

9. Conditioning

9.1 Condition the test specimens in conformance with Practice D 685.

10. Procedure

10.1 Place the 1.0-m Bristow wheel into its rotational support mechanism.

10.2 Set the rotational speed to 7.5 cm/min.

10.3 Mount a test specimen tightly onto the Bristow wheel by affixing each end firmly with adhesive tape. Record which side of the test specimen (see 8.2.3) is outermost, and which will be in contact with the liquid applicator.

10.4 Draw up 50.0 µL of test fluid (reagent water) into the fluid measuring device and discharge it across the slot of the applicator by inserting the delivery tip of the fluid measuring device down through the fluid applicator reservoir. Replace the tip of the fluid measuring device if it is replaceable, or clean the device thoroughly, after each series of measurements.

10.5 Observe the liquid in the applicator. Use the monofilament polyester to distribute the liquid across the applicator slot if an air bubble, gap, or separation is noted in the liquid film across the slot.

10.6 Place the wheel and test specimen into rotation at the required speed of 7.5 cm/min.

10.7 With the wheel in motion at the required speed, lower the applicator onto the test specimen, allowing it to exert the required pressure (see 6.1.2.2) and begin the test.

10.8 Lift the applicator from the test specimen after the test fluid band is complete (all fluid discharged from the applicator), as evidenced by no further extension of the fluid band on the test specimen. If fluid remains in the applicator at or near the end of the test specimen after the wheel has completed nearly one complete revolution since beginning the test, the required test conditions may be inappropriate for the particular paper and the results may be invalid, or both.

10.9 Carefully remove the test specimen from the wheel.

10.10 Immediately mark, with a pencil and a straightedge, the starting point of the test fluid band, and the end point of the fluid band. If the band seems to trail off at the end, estimate the place where the fluid band would have ended had it remained constant in width.

10.11 If the applicator is to stand idle, for example at the end of a series of test, wash the applicator with water or some other solvent appropriate for the test fluid used, if it was not the required reagent water.

10.12 Dry the applicator with acetone or methanol for storage or between tests with differing test fluids.

10.13 Always be sure that the applicator is clean and dry before beginning a series of tests.

10.14 Washing is unnecessary during a period when the applicator is in constant use, provided residual liquid does not dry in the applicator.

11. Calculation

11.1 Measure as the length of the solvent band on the test specimen the distance between the two marks made on the test specimen (see 10.10) to the nearest millimetre.

11.2 Measure the width of the solvent band at several locations along its length. Use a magnifying glass to make readings to the nearest 0.1 mm. Calculate the average width to the nearest 0.1 mm.

11.3 For each test specimen, calculate the amount of liquid sorbed per unit area using the following formula:

$$Q = \frac{(1000)q}{p \times r} \quad (1)$$

where:

Q = liquid sorbed, mL/m^2,
q = amount of liquid added to applicator, µL,
p = solvent band length, mm, and
r = average band width, mm.

11.4 Calculate separately the average value of Q for the wire and felt (or "top" and "bottom") surface of each sample by dividing the sum of the Q values for a particular sample side by the number of values in the sum.

11.5 Calculate the time available for liquid sorption using the following formula:

$$t = \frac{w}{V} \quad (2)$$

where:

t = time available for sorption, s,
w = width of the applicator slot in the direction of the Bristow wheel travel, plus width of the trailing edge of the applicator, mm, and
V = circumference speed of the Bristow wheel, mm/s.

NOTE 2—As specified in 6.1.2.1, the width of the slot in the applicator is 1.00 mm, and the width of the applicator trailing edge is 1.0 mm, thus the value of "w" for the standard conditions specified in this test method is 2 mm. Likewise, the specified circumference speed of the Bristow wheel is 1.25 mm/s for the standard test conditions.

11.5.1 When the instrument is used in the standard manner described in this test method, the value of t is 1.6 s.

12. Report

12.1 Report the following information:

12.1.1 The average volume of liquid transferred to the wire side (top side) of the sample in millilitres per square metre.

12.1.2 The average volume of liquid transferred to the felt side (bottom side) of the sample in millilitres per square metre.

12.1.3 Relevant visual observations, including:

12.1.3.1 Uniformity of the test fluid laydown on the specimen surface.

12.1.3.2 Degree of feathering of the edge of the band of the test liquid on the specimen.

12.1.3.3 Any sign of complete penetration of the test fluid through the specimen.

12.1.4 Deviations from any of the testing conditions specified in this test method, if any, including, but not limited to, test liquid composition, specimen size, Bristow wheel size, and Bristow wheel speed.

12.1.4.1 Time available for sorption (see 11.5.1). Where any deviations in wheel speed or applicator slot have been made, calculate and report the time available for sorption using (Eq 2).

12.1.4.2 If a different calculation for sorption time is used, specify the calculation formula used.

13. Precision and Bias

13.1 *Precision*:

13.1.1 *Repeatability*—The repeatability standard deviation calculated as specified in Practice E 691 is 0.4 mL per m^2. The 95 % repeatability limits for two results obtained in the same laboratory are 1.10 mL per m^2. These repeatability data were derived from test data obtained in four different laboratories on seven different papers having an average result for short term penetration of liquid as measured by this test method of 15.5 mL per m^2. There was no indication that the repeatability varied as a function of the test result.

13.1.2 *Reproducibility*—The reproducibility of this test method is under study.

13.2 *Bias*—No statement is made about the bias of this test method because the values obtained by this test method are defined only in terms of the specific conditions of this test method.

14. Keywords

14.1 alcohol; Bristow test; Bristow wheel; ink; liquid penetration; paper; paperboard; sizing; sorption; water penetration; wetting

APPENDIX

(Nonmandatory Information)

X1. GENERAL USE OF THE BRISTOW TEST

X1.1 This test method describes only certain limited applications of the Bristow technique. More comprehensive approaches to understanding and using the technique have been published **(1,2)**[4]. These approaches study the sorption of liquids onto paper by measuring the amount of liquid sorbed in a series of tests in which the time of sorption is varied from 0.01 to 4.0 s. The amount of liquid sorbed is plotted as a function of time, and the data are analyzed in ways that reveal information regarding roughness and intrinsic absorptiveness of paper surfaces.

X1.2 This test method provides a relatively simple standardized approach for using the Bristow technique to measure liquid sorption during the time period of 1.6 s. The standardized approach has been found useful for practical purposes such as prediction of ink drying times in bar coding and printing applications.

X1.3 The calculation of time available for liquid sorption (see (1)) is found in the work of Salminen **(3)**. Other formulae for this calculation using slot width alone have also been published.

X1.4 A related Japan Tappi Standard No. 51-87 for determination of liquid absorbability of paper and board has been published **(4)**.

[4] The boldface numbers in parentheses refer to a list of references at the end of the text.

REFERENCES

(**1**) Bristow, Svensk *Papperstidn.*, Vol 70, No. 19, 1967, pp. 623–629.
(**2**) Lyne and Aspler, *Tappi*, Vol 65, (12), December 1982, pp. 98–101.
(**3**) Salminen, P., *PhD Thesis*, Abo Akademi, Abo Finland, 1988.
(**4**) *Japan Tappi 41* (8) August 1987, pp. 609–702.