Designation: D 829 – 97 (Reapproved 2002)

An American National Standard

Standard Test Methods for Wet Tensile Breaking Strength of Paper and Paper Products[1]

This standard is issued under the fixed designation D 829; 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 These test methods measure the (wet) tensile breaking strength of paper, paper products, and paperboard (excluding corrugated board) when saturated with water.

1.2 These test methods are intended for use with papers and paper products that will be subjected to stress while wet during processing or use, including but not limited to tissue products, papers used in map-making, photography and blue prints, bags, and food wraps.

1.3 Two test methods are described; one for samples that are able to be handled while wet without damage, and one for samples, such as tissue, that are easily damaged or impossible to handle while wet.

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:*

D 585 Practice for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, and Related Product[2]

D 685 Practice for Conditioning Paper and Paper Products for Testing[2]

D 824 Test Method for Rate of Absorption of Water by Bibulous Papers[2]

D 828 Test Method for Tensile Properties of Paper and Paperboard Using Constant Rate of Elongation Apparatus[2]

D 1193 Specification for Reagent Water[3]

D 1968 Terminology Relating to Paper and Paper Products[2]

D 3285 Test Method for Water Absorptiveness of Nonbibulous Paper and Paperboard (Cobb Test)[2]

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, The Average for a Characteristic of a Lot or Process[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D 1968 or the *Dictionary of Paper*.[5]

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *finch wet strength, n*—tensile strength of a sample tested using Test Method B of these test methods.

4. Summary of Test Methods

4.1 These test methods consist of two test methods as follows:

4.1.1 *Test Method A*—Immersion Wetting Procedure, see 11.1.

4.1.2 *Test Method B*—Finch Procedure, see 11.2.

4.2 In Test Method A, a test specimen is immersed in distilled water at 23°C for the time period required to reach saturation as defined in these test methods that may be as long as 24 h. After saturation, the specimen is tested as described in Test Method D 828. Test Method A is suited for papers that can be handled wet without damage, including papers that retain a high percentage of their original (dry) strength when wet such as photographic, map, and blueprint papers, food wraps, and some bags.

4.3 In Test Method B, a test specimen is saturated with water in a Finch wet strength device and then tested as described in Test Method D 828. Test Method B is suited for papers that are highly absorbent, easily damaged when wet, or both, such as tissue paper, particularly absorbent towels. Saturation generally occurs in 5 to 40 s.

5. Significance and Use

5.1 Wet tensile strength is an important performance characteristic of papers or paper products that will be processed wet or that may be subjected to wetting, whether accidental or intentional, during use.

---

[1] These test methods are under the jurisdiction of ASTM Committee D06 on Paper and Paper Products and are the direct responsibility of Subcommittee D06.92 on Test Methods.

Current edition approved Dec. 10, 1997. Published November 1998. Originally approved in 1945. Last previous edition approved in 1995 as D 829 – 95.

[2] *Annual Book of ASTM Standards*, Vol 15.09.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Available from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Atlanta, GA 30348.

6. Apparatus

6.1 *Tensile Tester*—A tensile tester meeting the specifications found in Test Method D 828 is suitable for these test methods.

6.2 *Specimen Cutter*—A double blade strip cutter of the JDC-type, or similar cutting die complying with the requirements for a specimen cutter in Test Method D 828 is suitable for these test methods.

6.3 *Blotting Paper*—A quantity of sheets of blotting paper 200 mm^2 (8 $in.^2$) weighing 250 ± 10 g/m^2 oven dry, 0.495 to 0.521 mm (0.0195 to 0.0205 in.) thick and having a rate of absorption of 25 s or less when tested with 1.0 mL of water in accordance with Test Method D 824, and a capillary rise of 50 to 100 mm of water (mean of *MD* and *CD*) when measured in accordance with the Klemm Test in Annex A1 of Test Method D 3285. Required for Test Method A only.

6.4 *Dish*—A glass dish having a dimension of at least 300 mm (12 in.) in its shortest dimension, 50 mm (2 in.) deep is suitable. Required for Test Method A only.

6.5 *Finch Wet Strength Device*—A device allowing a specimen to be saturated with water and then tested without further handling. Required for Test Method B only. Two styles are available. Either one complies with these test methods.

6.5.1 *Finch Wet Strength Device (Older Style)*—A wet strength device (see Fig. 1) consisting of an inverted stirrup about 38 mm (1.5 in.) in width and about 76 mm (3 in.) in length, made of metal strap by which a horizontal rod about 28 mm (1.1 in.) in length and 5 ± 0.05 mm (0.188 ± 0.002 in.) in diameter is supported. Between the straps and under the horizontal rod is a small, vertically movable container for holding water or other liquid. The liquid container locks in its uppermost position, so that the horizontal rod is then immersed in the liquid to a depth of at least 19 mm (0.75 in.). A thin metal tang forming the lower part of the inverted stirrup permits it to be fastened in the lower clamp of a tension testing machine.

6.5.2 *Finch Wet Strength Device (Newer Style)*—A wet strength device (see Fig. 2) consisting of a stainless steel casting of approximately 110 mm (4.375 in.) total length. A thin bottom tang about 25 mm (1 in.) in width and 19 mm (0.75 in.) in length comprises the bottom portion of the casting. The upper portion of the casting consists of a rod of about 5 ± 0.05 mm (0.188 ± 0.002 in.) in diameter about 26 mm (1.03 in.) in length affixed and supported as part of the casting such that it extends freely in a direction perpendicular to the long direction of the casting approximately 44 mm (1.75 in.) below the top of the casting. A vertically moving liquid container is fastened to the body of the casting and is free to move such that when the liquid container is filled with fluid, it may be moved to a position such that the horizontal rod is immersed to a depth of at least 19 mm (0.75 in.).

6.5.3 The main difference between the old and new style Finch wet strength devices is that the new style provides easier, direct access to the rod under which the specimen must be inserted, thus specimen loading is simpler, easier, and more rapid.

6.5.4 Finch wet strength devices similar in design to that described in 6.5.1 or 6.5.2 are available with longer rods and larger fluid containers for use with specimens wider than 1 in. (25.4 mm). The rod of the Finch wet strength device must always be at least as long as the width of the test specimen.

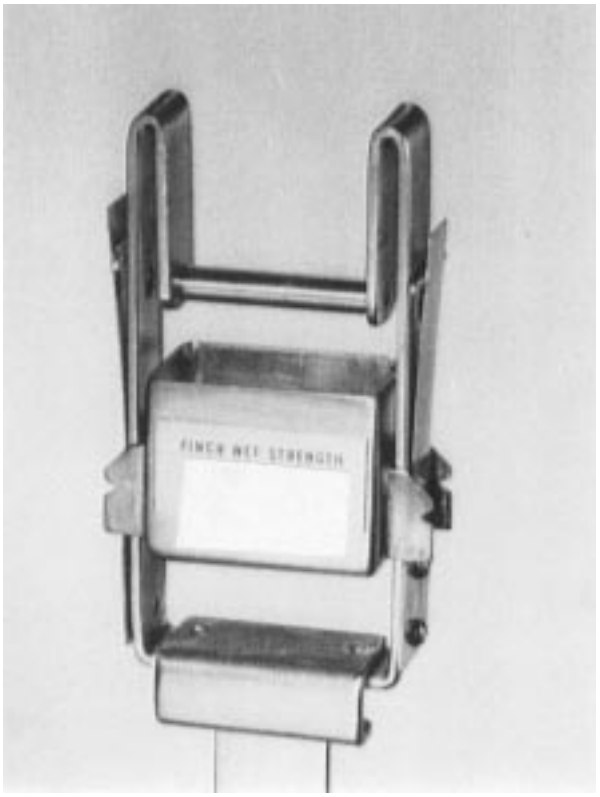

FIG. 1 Finch Wet Strength Device (Older Style)

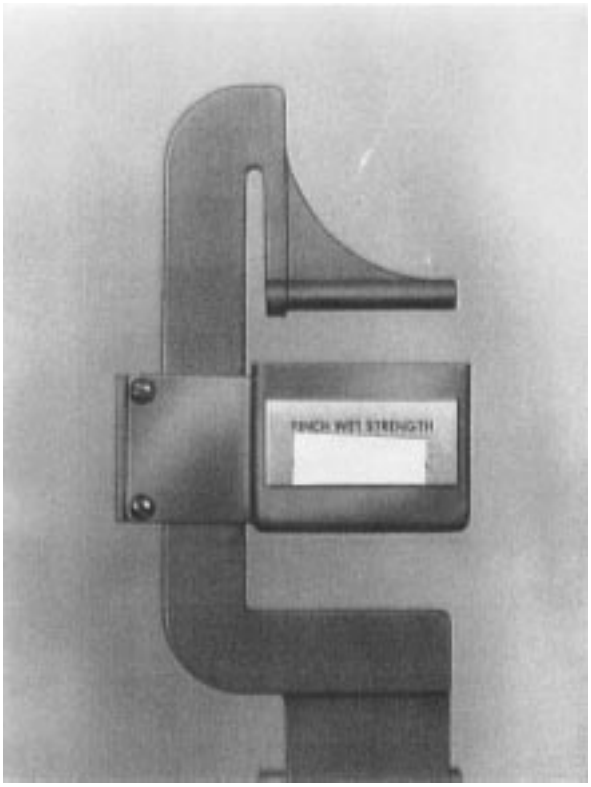

FIG. 2 Finch Wet Strength Device (Newer Style)

7. Reagents

7.1 *Distilled Water*—Any of the four grades of reagent water described in Specification D 1193 are suitable for use in making the measurements described in these test methods.

8. Sampling

8.1 *Acceptance Sampling*—Acceptance sampling shall be in accordance with Practice D 585.

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

9. Test Specimens

9.1 Cut at least ten test specimens from each test unit of the sample in each principle direction of the sample (machine direction and cross machine direction) 25.4 mm (1.00 in.) wide by at least 230 mm (9 in.) long as described in Test Method D 828.

9.2 Additional test specimens will be required for determining the time necessary to saturate the paper being tested. See 11.1.1 or 11.2.1.

10. Conditioning

10.1 Condition the samples in accordance with Practice D 685.

11. Procedure

11.1 *Test Method A—Immersion Wetting Procedure*—This portion of the procedure uses immersion in distilled water to achieve test specimen saturation, and is suitable for samples described in 4.2 which retain a high percentage of their original (dry) wet strength when wet including, but not limited to photographic, map and blueprint papers, food wraps and some bags.

11.1.1 Determine the immersion time required to saturate the paper as follows:

11.1.1.1 Immerse several machine direction test specimens in a dish of distilled water maintained at 23.0 ± 2.0°C (73.4 ± 3.6°F). Remove test specimens from the dish beginning at ¼ h after beginning immersion, and continuing to remove specimens at time intervals differing by a factor of 2; that is, ¼, ½, 1, 2, 4, 8 h, and so on, continuing until the difference in tensile strength between two immersion periods differing by a factor of 2, as determined by the procedure in 11.1.3 and 11.1.4 is less than 10 %. The longer of the two immersion periods is the immersion time to be used with the particular paper.

11.1.1.2 It is impossible to make any general statements regarding the immersion time required, as it varies considerably depending upon, but not limited to, factors such as sample caliper, basis weight, and sizings present.

11.1.2 Immerse the test specimens of a sample for the required immersion time as determined in 11.1.1.1 in a dish of distilled water at 23 ± 2°C (73.4 ± 3.6°F).

11.1.3 At the end of the required immersion time, withdraw the strip, lay it flat and straight on a pad of blotting paper, cover with an additional sheet of blotting paper, and press lightly to remove excess water.

11.1.4 Immediately after blotting, place the test specimen in the tensile testing machine and test as described in Test Method D 828.

11.1.5 Avoid the use of excessively high clamping pressures during testing. Apply only sufficient clamping pressure to prevent the specimen from slipping in the clamping jaws. Excessively high clamping pressure will result in straight line breaks in, and immediately adjacent to, the clamping zone. However, too low a clamping pressure will result in slipping or show an abrupt discontinuity in the load elongation curve with failure of the specimen beyond the clamping zone, or both.

11.2 *Test Method B—Finch Procedure*—This portion of the procedure uses the Finch wet strength device and distilled water to achieve specimen saturation, and is suitable for samples described in 4.3, including but not limited to papers that have low wet strength or are easily damaged when wet, or both, such as tissue paper, particularly paper towels.

11.2.1 Fasten a Finch wet strength device (see section 6.5.1 or 6.5.2) in the lower clamp of the tensile testing machine so that the horizontal rod is placed perpendicular to the axis of the two clamps and parallel to the clamp faces, and is otherwise symmetrically located with respect to the clamps. Adjust the position of the lower clamp so that the bottom edge of the horizontal rod is about 76 mm (3 in.) below the bottom edge of the upper clamp.

11.2.2 Move the liquid container to its lowest position and fill nearly to the top with distilled water at 23.0 ± 2°C (73.4± 3.6°F).

11.2.3 Perform testing as follows:

11.2.3.1 Wipe dry the horizontal rod and rod support components with highly absorbent tissue.

11.2.3.2 For the older style Finch wet strength device, thread the test specimen under the rod.

11.2.3.3 For the newer style Finch wet strength device, simply form a loose U-shaped loop from the specimen and slip the loop under the rod.

11.2.3.4 Place the ends of the specimen together, remove the slack, and fasten them in the upper clamp of the tension testing machine. Centrally locate the specimen with respect to the horizontal rod and upper clamps. Fig. 3 is a drawing showing an old style Finch wet strength device with sample in place in

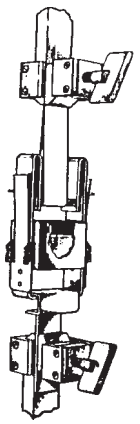

FIG. 3 Old Style Finch Wet Strength Device Installed in a Tensile Testing Machine With Sample in Place and Fluid Cup in Its Lowest Position Prior to Testing

a tensile testing machine. The fluid cup has been cut away to allow the water to be viewed. A similar drawing for the new style Finch wet strength device is not shown, but would differ only in the design features of the device itself.

11.2.3.5 With the specimen in place, raise the Finch cup containing distilled water (11.2.2) into the raised (highest) position and allow the specimen to soak for a period of time as determined in 11.2.4.

11.2.3.6 At the end of the soak period, while leaving the cup containing distilled water in the raised position, activate the tensile tester as described in Test Method D 828 and determine the tensile strength of the specimen.

11.2.3.7 Repeat 11.2.2 and 11.2.3.1 through 11.2.3.6 for each additional test specimen of the sample until at least ten test specimens for each sample have been tested.

11.2.4 Prior to testing specimens of a sample whose saturation behavior in the Finch procedure is unknown, take specimens as described in 9.2 and perform 11.2.2 and 11.2.3.1-11.2.3.6, varying the soak periods (11.2.3.5) prior to determining the tensile strength (11.2.3.6) beginning with 5 s, then 10 s, then 20, 40, 60, and 80s. When the decrease in tensile strength (11.2.3.6) is less than 10% for two consecutive time intervals of soaking, use the longer of the two times as the soak period required in 11.2.3.5. For specimens showing a continued decrease in strength greater than 10% after 80 s soaking, the use of the saturation procedure in 11.1 should be considered.

11.3 For Test Method B, calculate the average wet tensile strength in each principle direction by dividing the sum of all tests made by two times the number of specimen strips tested.

12. Calculations

12.1 For samples tested as described in 11.1, divide the sum of the wet tensile strengths of all of the specimens tested for a specific sample by the total number of specimens tested.

12.2 For samples tested as described in 11.2, divide the sum of the wet tensile strengths of all specimens tested for a specific sample by two times the total number of specimens tested.

13. Report

13.1 Report the following information:

13.1.1 Procedure used (Test Method A or Test Method B),

13.1.2 Wet tensile breaking strength as calculated in 12.1 or 12.2 for each principle direction of the paper,

13.1.3 Any deviation from the testing procedures described (see Annex A1).

14. Precision and Bias

14.1 *Precision*:

14.1.1 *Test Method A*:

14.1.1.1 *Repeatability*—The critical limits between which two tests, each of which is the average of ten determinations done in the same laboratory, will fall 95 % of the time is 9.4 %.

14.1.1.2 Reproducibility between laboratories is unknown.

14.1.2 *Test Method B*:

14.1.2.1 *Repeatability*—The critical limits between which two tests, each of which is the average of ten determinations done in the same laboratory, will fall 95 % of the time is 6.5 %.

14.1.2.2 Reproducibility between laboratories is not known.

14.2 These precision data were obtained in a single laboratory and consisted of a total of 231 samples of three different grades of paper tested by different operators in the case of Test Method A, and tests run on 25 samples of tissue papers tested by the same operator for Test Method B.

14.3 *Bias*—No statement is made about the bias of these test methods, as this property is defined only in terms of the specific testing procedures described in these test methods.

15. Keywords

15.1 blueprint papers; Finch wet strength; food wraps; map papers; paper; paper bags; paperboard; tissue products; wet tensile breaking strength

ANNEX

(Mandatory Information)

A1. TYPICAL VARIATIONS ON THE WET TENSILE BREAKING

A1.1 *Wet Strength Test Methods:*

A1.1.1 Numerous variations of these test methods have been found useful for specific papers and paper products, specific information needs, or both.

A1.1.2 Major variations include sample width, test fluids other than distilled water, and testing prior to saturation.

A1.1.2.1 With regard to sample width, both sample cutters and Finch wet strength devices can be obtained with width greater or less than the width specified in these test methods. In no cases can a Finch wet strength device ever be used for testing specimens wider than the length of the device rod. When testing is performed in an identical manner, the increase in sample width will generally cause an increase in measured wet strength which is directly proportional to the increase in sample width.

A1.1.2.2 No general statement can be made regarding the impact of fluids other than distilled water on results, as these will be influenced by any additives present in the test specimen or the materials present in the test fluid, or both. The action of distilled water to which are added various solutes, or solvents other than distilled water, may be of interest in a specific end-use application of a paper.

A1.1.2.3 When testing is performed on samples which are not saturated, such as, for example, with insufficient immersion

to comply with the conditions stated in Test Method A, results are frequently higher than those that would be achieved if these test methods were rigorously followed. Such data may be of interest for specific papers such as photographic or blueprint papers which are subjected to only short periods of fluid immersion, and are not expected to be used in a saturated state. However, such deviations from these test methods may not be reported as deviations from it because these test methods defines wet strength only in terms of a sample saturated with water.

A1.1.2.4 It has been common industry practice to place single or multiple strips of papers, such as tissue, which are easily damaged or impossible to handle when wet, into a tensile machine as described in Test Method D 828 and then wet them with a brush, sponge, spray, or similar means not consistent with that described in Test Method B and then perform testing. These results are frequently reported as "wet strength." Because the sample is not brought to a state of consistent, total saturation prior to testing, results using such procedures are generally less precise than those described in this standard, and give results which are generally higher by some undefined amount. Such deviations do not comply with the intent of these test methods that samples be tested after saturation with water in one of two ways, and in cases where such procedures are used, they may not be stated to comply with these test methods.

A1.1.2.5 Complete saturation of certain types of paperboard, particularly paperboard, may be significantly accelerated by immersion in degassed distilled water, ordinary distilled water at reduced pressure, or by the addition of a wetting agent. The addition of a wetting agent may affect the test results for some materials.

A1.1.2.6 After a prolonged immersion period, the pH change of the immersion water caused by the test specimen itself or the hydrolysis of any wet strength agent present, or both, may cause a further loss of strength in addition to that brought about by water itself.[6,7]

A1.1.2.7 In some cases, particularly for paper products such as towels, it may be impossible to obtain a specimen 230 mm (9 in.) long as required in 10.1. In such cases the distance specified in 11.2.1 (76 mm or 3 in.) between the bottom of the horizontal bar on the Finch wet strength device and the bottom edge of the upper grip must be reduced to accommodate the available sample. This is an allowable deviation from the conditions stated in 11.2.1, and must be reported in 13.1.3, giving the exact distance at which testing was performed.

A1.1.2.8 Any modifications agreed to by the buyer and the seller with regard to the procedures described in these test methods must be clearly documented, as required in 13.1.3. However, as stated in A1.1.2.3 and A1.1.2.4, any testing done on a sample which has not been saturated with distilled water may not be stated to comply with these test methods.

[6] Maxwell, C. S., and Reynolds, W. F., *TAPPI Journal 33*, Vol 4, 1950, p. 179.
[7] Maxwell, C. S., *TAPPI Journal 35*, Vol 5, 1952, p. 220.