Designation: D 828 – 97 (Reapproved 2002)

An American National Standard

Standard Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus[1]

This standard is issued under the fixed designation D 828; 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 Department of Defense.

1. Scope

1.1 This test method covers procedures for determining tensile properties of paper and paperboard.

1.2 The procedures given in this test method are for use with constant-rate-of-elongation tensile testing equipment and as such, may be used with instruments designed for either vertical or horizontal operation, and whether manually operated or computer controlled.

1.3 These procedures are applicable for all types of paper, paperboard, paper products, and related materials within the measurement limitations of the equipment used. They are not for use with combined corrugated board.

1.4 Properties that may be determined using this test method include tensile strength, stretch, tensile energy absorption, tensile stiffness, breaking length, and tensile index.

1.5 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.6 *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 Products[2]

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

D 987 Method of Test for Stretch of Paper and Paper Products Under Tension[3]

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

E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for 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 *line contact grips, n*—grips or jaws on a tensile testing machine having a clamping zone for gripping the specimen comprised of a cylindrical and a flat surface or two cylindrical surfaces whose axes are parallel.

4. Significance and Use

4.1 The tensile properties measured in this test method are fundamental properties associated with the manufacture, or end use, or both, of paper and paper products. They may be influenced by, or indicative of the type fibers used or the treatment of the fibers, or both, in a particular paper. They may also be influenced by or indicative of specific manufacturing procedures used in producing a specific paper or paper product. Likewise, paper converting operations may significantly impact properties measured using this test method, and this test method may be used to measure and understand such effects.

4.2 Tensile strength is indicative of the serviceability of many papers, such as wrapping, bag, gummed tape, and cable wrapping, that are subjected to direct tensile stress. The tensile strength of printing papers is indicative of the potential resistance to web breaking during printing and other converting operations and during travel of the web from the roll through the equipment.

4.3 Stretch, and sometimes tensile stiffness are indicative of the ability of the paper to conform to a desired contour. These are important properties of creped papers, towels, napkins, decorative papers, industrially used paper tapes (both creped and pleated), bags, and liners for cans, barrels, and cartons.

4.4 Tensile energy absorption is a measure of the ability of a paper to absorb energy at the strain rate of the test, and

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[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.

Current edition approved Dec. 10, 1997. Published November 1998. Originally approved in 1945. Last previous edition approved in 1993 as D 828 – 93.

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

[3] Discontinued, see *1968 Annual Book of ASTM Standards*, Part 15.

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

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

indicates durability of papers that are subjected to repetitive straining and stressing, such as multiwall sack papers.

4.5 Tensile stiffness often gives a better indication of the mechanical response of the sheet to converting forces than do tensile rupture criteria.

5. Apparatus

5.1 *Tensile Testing Machine*, of the constant-rate-of elongation type conforming to the following criteria:

5.1.1 Two line contact grips or jaws for gripping the test specimens, with the line of contact perpendicular to the direction of the applied load, and with means for controlling and adjusting the clamping pressure.

NOTE 1—There are certain grades of paper that may be damaged by line contact grips. In these cases, as agreed upon between the users of this test method, other grips may be substituted, and that fact stated in the report.

5.1.1.1 The clamping surfaces of the two grips must be in the same plane and so aligned that they hold the test specimen in that plane throughout the test.

5.1.2 The distance between the line contact gripping zones of the grips at the beginning of a test must be adjustable and resettable to ±0.5 mm (±0.02 in.) for the specified initial test span (see 8.1 and 10.3.2).

5.1.3 The rate of separation of the two grips must be 25.4 ± 5.0 mm/min (1.0 ± 0.2 in./min) or as otherwise noted (see 10.3.4), and once set, must be resettable and constant at the required rate to ±4 % of the specified value.

5.1.4 The tensile testing machine must be equipped with a load measuring device and a recorder or other suitable indicator of the measured load at points of interest during the test, an example of which might be a micro processor and digital readout device or cathode ray tube screen, capable of reading the measured loading force accurately to 0.25 % of the full range of the load measuring device. The load measuring circuitry must be capable of accurate calibration, and must maintain that calibration accuracy to ±0.5 % of the full-scale value.

5.1.5 The tensile testing machine must be equipped with an elongation measuring device and a recorder or other suitable indicator of the measured elongation at points of interest, an example of which might be a microprocessor and digital readout device or cathode ray tube screen, capable of accurate calibration and of indicating the elongation values to a readability and accuracy of ±0.05 % stretch (that is ±0.09-mm elongation for an original specimen test span of 180 mm).

5.1.6 The tensile testing machine must be capable of providing the measurement data required for making the calculations specified in Section 11, whether by presentation of data in the form of a recorder trace of the tensile force-elongation behavior of the material being tested such that data required by the user can be readily determined from the recorder trace, or whether by storage of required data points in a form usable and retrievable by the user for calculations as specified in Section 11, or whether by including calculation algorithms suitable for direct display of the calculations specified in Section 11. Where calculation algorithms are included, it is the responsibility of the manufacturer of the instrument to clearly document the calculation basis for the values that are reported, and that they do or do not comply with the calculations specified in Section 11. The user of the instrument must, in turn, determine that reported values are suitable for any particular information need. Numerous other calculations may be based on the tensile strength-elongation of a material, and may be included in an instrument used for making the measurements described in this test method, as agreed upon between the manufacturer and the purchaser of the instrument.

5.2 *Alignment Jig*, to facilitate centering and aligning the specimen in the instrument grips, so that the clamping lines of contact are perpendicular to the direction of the applied force and the center line (long dimension) of the specimen coincides with the direction of the applied force. Use optional, as agreed upon between the users of this test method. Such a device is described in TAPPI Journal **(1)**[6].

5.3 *Planimeter or Integrator*, to measure the area beneath the load-elongation curve or to compute directly the work to rupture. The specific characteristics of the testing machine used will dictate the need for this device. Most modern electronic tensile testing machines include the necessary calculation capabilities in the software resident in the instrument. See 5.1.6.

5.4 *Specimen Cutter*, a device capable of cutting specimens for testing that are uniform in width to within at least ±0.5 mm (±0.02 in.) or less of the specified specimen width, and with edges parallel to within 0.1 mm (0.004 in.). The double-blade strip cutter of the JDC-type is quite satisfactory for this requirement. Other cutting dies may also be used, provided they are found to comply with or exceed the tolerances stated herein. Single-blade "paper cutters" do not comply with the requirements for a specimen cutter for purposes of this test method.

5.5 *Magnifier and Scale or Similar Optical Comparator*, for use in measuring specimen widths and determining that specimens comply with 5.4. It is important to understand that the requirements of 5.4 apply to the test specimen, not to the specimen cutter. The tolerances to which the cutter or cutting die itself must be designed are those that produce *test specimens* of the stated tolerance.

NOTE 2—Automated tensile testing instruments providing automated sample handling, laboratory management, or data acquisition, or any of these in combination, are available. These instruments provide features not limited to calibration, calibration check, automation of testing sequence, storing of testing programs including rate of grip separation or distance of grip separation, or both, cutting of test strips, acquiring of test data, and accurately determining tensile breaking properties including those listed in Section 11. This test method may be used with any such equipment, provided the equipment complies with the requirements of Section 5.

6. Sampling

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

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

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

7. Test Specimens

7.1 The standard dimension for test specimens required for performing this test method is 25.4 ± 0.5 mm (1.00 ± 0.02 in.) wide and of such length, usually about 254 mm (10.0 in.) to allow sufficient specimen for clamping in the instrument grips when the standard distance between the grip clamping zones is 180 ± 5 mm (7.1 ± 0.2 in.).

7.1.1 A common width dimension, found in many ISO Standards and used for some specific grades of paper based on specification or agreement between the buyer and the seller, is 15.0 mm (0.591 in.). The limits of precision for the specimen width stated in 5.4 apply (±0.5 mm [±0.02 in.]), thus the narrower specimen width may introduce a slightly greater variability into tensile strength results, and values calculated from tensile strength such as breaking length.

7.1.2 Specifications requiring specimen widths other than those in 7.1 and 7.1.1 may be encountered. Specimen width used must always be included in the report when it deviates from 7.1. The impact of specimen width is addressed in Annex A1.

7.2 From each conditioned test unit of the sample, cut ten test specimens in each of the two principle directions of the paper having the dimension stated in 7.1 using a specimen cutter complying with 5.4.

7.3 Ensure that the specimen strips chosen for testing are free from abnormalities such as creases, holes, wrinkles, or other features not typical of the paper itself that may impact tensile strength values.

7.4 In some cases, particularly including converted paper products, it may be impossible to obtain specimens complying with 7.1 with regard to specimen length, or 7.3 with regard to freedom from abnormalities, or both, because of perforations, folds, embossing, printing, or other deliberately added product design features. In such cases, as agreed upon between the buyer and the seller, or required in relevant specifications, smaller initial distance between the two instrument grips may be required, with accompanying requirements for shorter test specimens. In addition, a change in rate of grip separation may be required. In such cases the deviation from this test method must be reported. Further information on these points may be found in Annex A1.

7.5 In some cases, it may be agreed upon between the buyer and the seller, or required in relevant specifications to perform testing on test specimens of lesser or greater width than that specified in 7.1. In such cases, the deviation from this test method must be reported. Further information on this point may be found in Annex A1.

8. Calibration

8.1 Because of the large number of tensile testing machines available that conform to the requirements of 5.1, specific calibration procedures for individual instruments is beyond the scope of this test method, and must be obtained from the manufacturer of the equipment. The following are general considerations that must be included, along with other considerations unique to specific instruments, as part of calibration procedures for use with this test method.

8.1.1 Regularly inspect the machine for cleanliness and for faults such as wear, misalignment, loose parts, or damage. Clean, grease, or otherwise service the machine at regular intervals, as recommended by the manufacturer or determined by the user of a particular machine. Make all necessary repairs when faults are found.

8.1.2 Level the machine accurately in the two principle directions using a carpenter's level or similar device.

8.1.3 Align the clamping grips that hold the specimen in the plane of the applied load, as required in 5.1.1.

8.1.4 Position the specimen grips as required in 5.1.2, or as agreed upon between the buyer and the seller in 7.4. Correct distance between the required line contact gripping zones may be verified by measuring the distance between the centers of the line clamp impressions produced on strips of thin metal foil.

8.1.5 Determine and adjust the clamping pressure on the specimen grips so that neither slippage or specimen damage occurs. Papers prepared from more highly hydrated or beaten fibers, such as tracing paper or glassine, present the most difficult gripping problems. For use with the widest possible range of papers, adjustment of grip pressure by making tests on strong tracing paper is generally satisfactory. Excessive pressure at the grip is evidenced by straightline breaks in, and immediately adjacent to the clamping zone. Insufficient pressure is evidenced by an abrupt discontinuity in the measured tensile strength prior to specimen rupture, or a wider than normal impression of the clamping line on the specimen after rupture, or both. Some level of experimentation will be required to achieve a satisfactory clamping pressure for specific types of paper or paper products.

8.1.6 After it is established that the testing machine is in good working order and has been properly leveled, periodic calibration of the load measuring system with standard weights is required. For referee testing and to comply with many different quality management programs, or both, the weights used should have traceability to a national standardizing organization such as NIST. Weights covering the entire range of the load-measuring component in the testing machine should be available, and should include about ten weights spaced fairly evenly thoughout the measuring range. Attach the weights to the clamp connected to the loadmeasuring device in a suitable manner or as directed in the instrument instructions, being sure to eliminate the weight of any weight support from the indicated value of the weight itself. Note the value measured when the system is in equilibrium. As stated in 5.1.4, allowable deviation from true weight is ±0.5 % of the full-scale range of the measuring component.

8.1.7 Periodic verification of the extension measuring system is required. Set the clamping grips to a specific separation as required in 5.1.2 or agreed upon based on 7.4. Verify the exact separation of the grips to the nearest 0.05 mm using a caliper of verified accuracy. Operate the grip separating system (commonly called the cross head on vertical tensile testing machines) as specified in 5.1.3 for a desired time period, measured to the nearest 0.1 s. Based on the speed at which the cross head is set to travel (25.4 mm/min as specified in 5.1.3, or some other speed) calculate the expected distance between