



Standard Test Method for Resistance to Bending of Paper and Paperboard (Taber-Type Tester in Basic Configuration)¹

This standard is issued under the fixed designation D 5342; 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 a procedure used to measure the resistance to bending of paper and paperboard.

1.2 The bending moment required to deflect the free end of a 38-mm (1.5-in.) wide vertically clamped specimen 15° from its center line when the load is applied 50 mm (1.97 in.) away from the clamp is determined. The resistance to bending is calculated from the bending moment.

1.3 Some instruments of the type described in this test method (see Section 6) may be equipped with ultrasensitive attachments or may be modified to accommodate shorter specimen lengths than that specified in this test method (see Section 9).

1.4 Test Method D 5650 describes a modification of the instrument described in this test method for measurements in the 0 to 10 Taber stiffness range only, and which requires a smaller test specimen. The modified procedure may be recommended for papers which are low in grammage or highly flexible, or both.

1.5 Test results obtained using modifications of the basic Taber-type instrument such as that described in Test Method D 5650 have been reported to be as much as 40 % different from those obtained using this test method, and such modifications must not be used when this test method is specified.

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, or Related Products²

D 685 Practice for Conditioning Paper and Paper Products for Testing²

D 1968 Terminology Relating to Paper and Paper Products²

D 5650 Test Method for Resistance to Bending of Paper of Low Bending Stiffness (Taber-Type Tester in the 0 to 10 Taber Stiffness Unit Configuration)²

E 122 Practice for Calculating Sample Size to Estimate, with a Specified Tolerable Error, the Average for Characteristic of a Lot or Process³

3. Terminology

3.1 *Definitions*—Definitions shall be in accordance with Terminology D 1968 and the *Dictionary of Paper*.⁴

4. Summary of Test Method

4.1 A test specimen of defined dimensions is bent through a specified angle using a specific testing instrument. The resulting bending moment is read from the instrument scale.

4.2 The resistance to bending can be calculated from the bending moment.

5. Significance and Use

5.1 Bending resistance of paper relates to a number of end-use applications including wrapping, printing, copy machine performance, high-speed mechanical handling of documents, and other applications.

6. Apparatus

6.1 Description:

6.1.1 The basic instrument that has been used for the test described in this test method for nearly fifty years is a manually operated (crank-driven) instrument. Over the years, various improvements in the basic instrument have been made for improved ease of use or greater reproducibility of data, or both. These improvements include replacement of the manual (crank) drive system with a constant speed motor, addition of automatic data determination, and automated instrument (motor sequencing) operation. Fig. 1 shows the motor-driven version of the instrument (see 6.1.2). It is the motor-driven model of the basic instrument that is the basis for this test method. However, any of the instrument variations described

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 1993. Last previous edition approved in 1995 as D 5342 – 95.

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

³ *Annual Book of ASTM Standards*, Vol 14.02.

⁴ Available from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Atlanta, GA 30348.

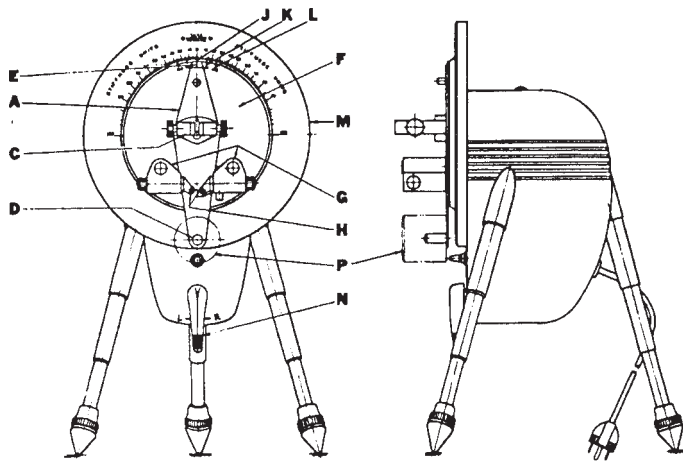


FIG. 1 Stiffness Instrument

in this section, when properly calibrated and operated, should yield the same result. The components of the basic instrument can be seen in Fig. 1 as follows:

6.1.1.1 A pendulum (A) supported in antifriction in bearings, carrying a vise (C) that has two clamping screws for holding and centering the test specimen, the lower edge of the vise coinciding with the center of the pendulum bearing. The pendulum is balanced, and at its lower end is a stud (D) to which weights may be attached and that loads the pendulum at a distance of 100 ± 0.025 mm (3.94 in.) from its center; without added weights the loading is 10 ± 0.001 g. A line (E) coinciding with the center line of the vise jaws and the weight stud (D), is engraved at the upper end of the pendulum.

6.1.1.2 A vertical disk (F), driven on the same axis as the pendulum by a driving mechanism, carried two driving arm attachments (G) so located as to provide the specimen with a cantilevered loading length of 50 ± 0.025 mm (1.97 in.) when it is deflected 15° . Fig. 1 does not show the crankdriving mechanism. The driving arms have rollers (H) that are adjustable to accommodate specimens of different thicknesses. On the periphery of the upper part of the disk is a marked line (J) coinciding with the center line between the driving rollers (H) and the axis, and two reference lines (K and L) are engraved on the periphery of the disk at angular distances of 7.5° and 15° on both sides of the center mark (J).

6.1.1.3 Located around the periphery of the disk (F) is a fixed annular disk (M) with a load scale from 0 to 100 on both sides of a zero point that is adjusted to coincide with the center line mark (J), the scale indicating the bending moment required to flex the specimen to the right or to the left, the divisions being in accordance with the sine of the angle through which the pendulum and weight are turned.

6.1.1.4 Various loading weights (P) for the pendulum, to give a maximum bending moment of 5000 g-cm (490 mN·m).

6.1.2 For operator convenience and improved testing reproducibility, the “driving mechanism” (crank) of the basic unit was replaced by a motor to drive the vertical disk (F) at a constant rate of $210 \pm 20^\circ$ per minute. Other than this change, the motor-driven instrument has the components of the “basic instrument” as described in 6.1.1. The motor is reversible using the switch (N), that preferably also operates an electric brake to

stop the disk at any point on the scale. The motor-driven version of the instrument shown in Fig. 1 is the instrument in most wide use today, and is the basis of this test method.

6.1.3 More recently, automated versions of the basic instrument have become available. These are two types: automatic reading of results (only), and automation of instrument operation as well as reading of results.

6.1.3.1 Devices are available that may be retrofitted to the basic instrument for automatically determining and recording the scale readings (see section 10.2). Results are displayed on a digital readout device. In addition, the retrofitted unit may provide a signal output suitable for transmission to a stand-alone printer or an integrated acquisition system.

6.1.3.2 Totally automated versions of the basic motor-driven instrument (see 6.1.2), incorporating the components described in 6.1.2.1, and in addition automatically controlling the entire sequence of operations described in 10.2, are also available.

7. Sampling

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

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

7.3 In sampling, take care not to bend, roll, score, or otherwise damage the area to be tested.

8. Test Specimens

8.1 From each test unit cut five test specimens, 38.1 ± 0.3 mm (1.50 ± 0.01 in.) wide by 70 ± 1 mm (2.75 ± 0.05 in.) long, with the length parallel to the machine direction. Cut another set of five test specimens with the length at right angles to the machine direction. All cut specimens must be free from scores or blemishes. A special cutter for cutting the samples may be available from the vendor, or a high-precision cutting board may be used.

9. Preparation of Apparatus

9.1 Place the instrument on a firm, level surface. A standard laboratory bench is generally quite satisfactory and should be checked with a carpenter’s level to verify that it is level (front-to-back, side-to-side) when the instrument is initially installed. Set the loading disk (F) at zero and place a chosen weight (P) on the pendulum stud. If possible, choose a weight such that the resulting readings for the specimen to be tested are near the center of the measured test range. Close the two jaws of the vice (C) to meet on the center line of the pendulum and adjust the legs of the instrument so that the engraved mark (E) coincides with zero on the scale of M. Level the instrument front to back as well as side to side.

9.2 Displace the pendulum 15° and release it to check the bearing friction. It should make at least 20 complete swings before coming to rest. If it does not, check for obvious contamination by dust particles. In the absence of any obvious problem, contact the vendor to arrange service or maintenance.

9.3 If the instrument has a brake, check that it functions properly. It should “freeze” (stop and securely hold) the rotating disk (F) in place within less than a second of its

application so that the result can be easily determined. (Operation of the brake on the automated instrument is automatically controlled as part of the automatic reversal from clockwise to counterclockwise (or vice versa) rotation.)

10. Calibration

10.1 Calibrate the instrument and check the accuracy of the apparatus at regular intervals. The method of calibration depends on the type of instrument and done following the manufacturer's instructions for the instrument used. Spring steel test pieces supplied by the manufacturer of the instrument for calibration purposes are generally used. If readings within the tolerance suggested by the manufacturer are not achieved, it may be necessary to return the instrument for servicing.

11. Conditioning

11.1 Condition the specimens and make the tests in an atmosphere in accordance with Practice D 685.

12. Procedure

12.1 Place a conditioned test specimen in the vise (C) with one end approximately level with its top edge and the other end between the rollers (H).

12.2 With the two clamping screws of the vise (C) align the specimen with the center line of the pendulum.

12.2.1 Pressure of the clamping screws may impact test results, and clamping pressure should be firm enough to hold the specimen, but not so firm as to compress or deform it.

NOTE 1—At the present time use of calibration spring steel or specimens of samples of known stiffness as determined by this test method are the only recommendations for determining if vise pressure is so great or so slight that test results are affected adversely.

12.3 Turn each of the screws for adjusting the rollers (H) so that they just contact the specimen, then after taking up the backlash in one screw, back off one-quarter turn to give a distance between rollers of $0.33 + 0.03$ mm ($0.013 + 0.001$ in.) greater than the thickness of the specimen.

NOTE 2—On instruments not equipped with adjustable rollers (H), use the appropriate set of rollers for the thickness of the board to be tested. It is not necessary for the pendulum to balance at zero with the undeflected specimen in place. Curvature of the specimen will result in a difference between the two readings which is averaged to give the stiffness of the specimen. This difference has been used as a measure of curl, but this should be done with caution, as this difference may also reflect a genuine difference in stiffness between the two orientations of the specimen with respect to the deflecting force. If the specimen is so badly curled that both readings fall on the same side of zero, take the lower reading as negative when calculating the average. Include mention of this occurrence in the report, as this much curl may make the material useless for its intended purpose.

12.4 *For the Basic Motor-Driven Instrument*—Switch on the motor to rotate the loading disk (F) to the left and thus deflect the specimen until the engraved mark (E) on the pendulum is aligned with the 15° mark (L) on the loading disk. Stop the motor, record the scale reading on the fixed annular disk (M), and immediately return the loading disk to zero (see Note 2). Take a similar reading by deflecting the specimen to the right. The stiffness of the specimen is taken as the average of the two readings multiplied by the factor required for the

instrument range weight used (see the manufacturer's instructions). Test five specimens cut in each direction.

NOTE 3—When the motor is "stopped," an electric brake immediately stops the disk and holds it in place so a reading can be taken. On instruments not equipped with an electric brake, take the reading as the disk rotates over the end point.

12.5 For the basic motor-driven instrument retrofitted with digital readout, the scale readings are automatically "captured" and are recorded from a digital display. The motor is started, stopped, and reversed in accordance with 12.4.

12.6 *For the Automated Instrument*—The operations described in 12.4 are automatically done in sequence after the test is initiated. Scale readings (left and right) are displayed on the instrument readout.

12.7 If the specimen is very stiff, or if it creases or checks when flexed as much as 15° , use the 7.5° deflection mark (manual instrument) or 7.5° deflection setting (automated instrument). Multiply the results by 2.0 for an approximate comparison with the 15° deflection. If a 7.5° deflection is so used, state this clearly in the report.

13. Calculation

13.1 *Bending Moment*—Calculate the bending moment as the average of the two readings (left and right deflection) multiplied by the factor required for the chosen weight, P , that was used during the test (see the manufacturer's instructions).

13.2 Where SI results are desired, convert the value in stiffness to millinewton metres by multiplying by 0.098066.

13.3 *Resistance to Bending*—Divide the bending moment (mN·m) by the length (m). Result is force (mN) required to deflect the sample through the specified distance (Length (m) = 0.050 m).

14. Report

14.1 Report the following information:

14.1.1 *Bending Moment*:

14.1.1.1 The average value in stiffness units or millinewton metres of the specimen tested from each unit cut in each direction separately, to three significant figures.

14.1.1.2 The number of specimens tested in each direction.

14.1.1.3 The standard deviation for each test unit.

14.1.1.4 The test method used for the test and the weight, P , (or instrument range) used for the test.

14.2 The resistance to bending calculated from the bending moment (see 13.3), to three significant figures.

15. Precision and Bias

15.1 *Precision*—The following estimates of repeatability and reproducibility, calculated as the percentage coefficient of variation, were determined in an interlaboratory study⁵ conducted using cylinder and fourdrinied paperboards:

15.1.1 *For 0 to 100-g-cm scale*:

15.1.1.1 Repeatability = 3 to 5 %.

15.1.1.2 Reproducibility = 9 to 20 %.

⁵ Verseput, H. W., "Precision of the Taber Stiffness Test," *TAPPI Journal* 52, Vol 6, 1969, p. 1136.

15.1.1.3 The larger variability in data occurs in the lower portion of the 0 to 100-g-cm scale range, decreasing to the smaller of the above figures at 100 g-cm.

15.1.2 *For 0 to 500-g-cm scale:*

15.1.2.1 Repeatability = 3 %.

15.1.2.2 Reproducibility = 10 %.

15.2 *Bias*—Various styles of stiffness testers are available for making measurements similar to those described in this test method. Bias among them is undefined, as each uses specific test conditions and conventions in expressing results which are defined in terms of specific test methods associated with the various testers.

15.2.1 The procedure in this test method is reported to give results differing by as much as 40 % from those produced by Test Method D 5650 which uses the same style test instrument in a different configuration. A systematic study of the bias between these two procedures has not been completed.

16. Keywords

16.1 bending; paper; paperboard; resistance to bending; stiffness; taber stiffness

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).