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T 566

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SUBJECT CATEGORY Physical Properties

RELATED METHODS See "Additional Information"

CAUTION:
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Bending resistance (stiffness) of paper (Taber-type tester in 0 to 10 Taber stiffness unit configuration)

(Five-year review of Official Method T 566 om-15)

(Changes from Draft 1 are incorporated. No changes from Draft 2)

1. Scope

1.1 This test method covers a procedure used to measure the resistance to bending of papers which are of low grammage, or high flexibility, or both, and which exhibit bending stiffness in the range of 0 to 10 Taber stiffness units.

1.2 This test is used to determine 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 10 mm (0.39 in.) away from the clamp. The resistance to bending is calculated from the bending moment.

1.3 The instrument used in this test method is identical to that described in TAPPI T 489 "Bending Resistance (stiffness) of Paper and Paperboard (Taber-type tester in basic configuration)," used in the modified

configuration described in section 6.2.4. Preparation of Apparatus. The 0-10 unit test range magnifies the scale indication ten times so that flexible materials can be tested below the standard range of the pendulum (0-100 Taber stiffness units).

1.4 Test results obtained using the Taber-Type Tester as described in this test method have been reported to be as much as 40% different from those obtained using TAPPI T 489, and this test method must not be used where TAPPI T 489 is specified.

1.5 Other procedures for measuring bending resistance include TAPPI T 535 "Bending Stiffness of Paper and Paperboard (Resonance Length Method)"; TAPPI T 543 "Bending Resistance of Paper (Gurley-Type Tester); TAPPI T 556 "Bending Resistance of Paper and Paperboard by Single-Point Bending Method"; and TAPPI T 836 "Bending Stiffness, Four Point Method." TAPPI T 535 has been classified as a Classical Method.

2. Summary of test method

2.1 A test specimen of defined dimensions is bent through a specified angle using a specific testing instrument. The resulting bending moment is calculated according to 11.1.

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

3. Significance and use

3.1 Bending resistance of paper having low grammage, high flexibility, or both relates to a number of end-use applications including wrapping, printing, copy machine performance, high-speed mechanical handling of documents and other applications.

4. Applicable documents

TAPPI T 400 "Sampling and Accepting A Single Lot of Paper, Paperboard, Containerboard, or Related Product;" TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products;" TAPPI T 489 "Bending Resistance (Stiffness) of Paper and Paperboard (Taber-Type Tester in Basic Configuration); TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility"."

5. Definitions

5.1 *Bending moment*, the torque in millinewton meters (force multiplied by the distance over which it is applied) required to deflect the test piece under the specified conditions of the test.

5.2 *Resistance to bending,* the force, in Newtons, required to deflect a rectangular test piece, clamped at one end, through a specified angle when the force is applied near the free end of the test piece, normal to the plane which includes the near edge of the test piece, the clamp, and the point or line of application of the force. Resistance to bending will vary if the angle, the width of the rectangular test piece, or the distance between the edge of the clamp and the application of the force are changed from those specified.

5.3 *Stiffness (or bending stiffness),* the degree to which paper or board resists bending when subjected to a bending force in its intended use, or when using a defined testing procedure such as the one described in this test method.

5.4 *Stiffness unit (or Taber stiffness unit),* the common unit of stiffness measure used with instruments of the type described in this test method. Most Taber stiffness testers are calibrated in multiples of this unit. One Taber stiffness unit (gram-force centimeter) is equal to 0.098066 millinewton meters.

6. Apparatus[1]

6.1 *Description:*

6.1.1 The components of the instrument (Figures 1 and 2) includes:

6.1.1.1 A pendulum (A) supported by anti-friction 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, at a constant rate of 210 ± 20º per minute. It carries two driving arm attachments (G) so located as to provide the specimen with a cantilevered loading length of 10 ± 0.025 mm (0.39 in.) when it is deflected 15° . 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), 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 vertical driving 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). This scale indicates the left and right deflection of the specimen which is used to calculate the bending moment (see 11.1), the divisions being in accordance with the sine of the angle through which the pendulum and weight are turned.

[1] Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list, available as part of the CD or printed set of Standards, or on the TAPPI website general Standards page..

Fig. 1. Digital version of instrument

6.1.1.4 A 10-unit compensating weight (X) to be mounted on the stud (Y) near the top of the pendulum when the instrument is used as described in this test method.

6.1.2 Automated versions of the instrument are available. There are two types: automatic display of scale readings (only), and automation of instrument operation as well as reading of results.

6.1.2.1 The automated versions automatically determine and record the scale readings (see Section 10.4); results are displayed on a digital readout device; in addition, the unit provides a signal output suitable for transmission to a stand alone printer or an integrated acquisition system.

6.2 *Preparation of Apparatus.*

6.2.1 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. 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.

6.2.2 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 instrument supplier to arrange service or maintenance.

6.2.3 If the instrument has a brake, check that it functions properly. It should “freeze” (stop and securely hold) the driving disk (F) in place immediately on 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 counterclockwise to clockwise (or vice versa) rotation.)

6.2.4 Conversion of the instrument to the 0 to 10 Taber stiffness unit range:

6.2.4.1 Remove and invert the two driving arm attachments (G) (right and left), as described in the manual for the instrument being used, changing the effective test length of the specimen from the 50 mm required in TAPPI T 489 to the 10 mm required in this test method. If your instrument is equipped with the sample stop feature, the sample stop must also be moved as described in the instrument manual.

6.2.4.2 Place the 10 unit compensating weight (X) on the stud (Y) near the top of the pendulum.

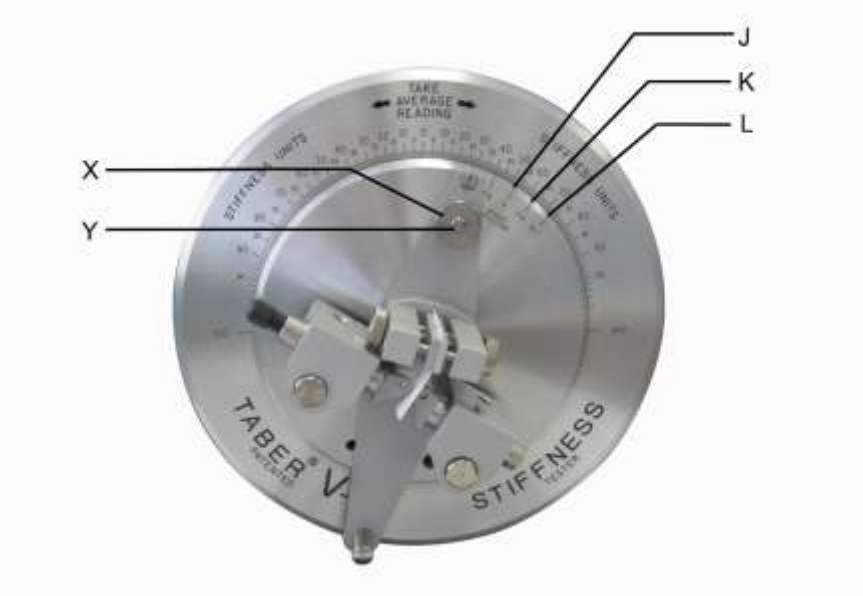

Fig. 2. Stiffness instrument

6.3 *Calibration.*

6.3.1 Calibrate the instrument and check the accuracy of the apparatus at regular intervals. Steel spring test pieces supplied by the manufacturer of the instrument are generally used to check calilbration. If readings within the tolerance suggested by the manufacturer are not achieved, it may be necessary to return the instrument for servicing.

7. Sampling

7.1 If a lot of paper is being tested to determine if it meets specifications, obtain a sample in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product," taking care not to bend, roll, score, or otherwise damage the area to be tested.

8. Conditioning

Condition the sample and make the tests in an atmosphere in accordance with TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products."

9. Test specimens

9.1 From each test unit cut five test specimens in each direction. Each test specimen shall be 38.1 ± 0.3 mm (1.50 ± 0.01 in.) square. At the very edge of each test specimen, mark or in some other way identify the machine or cross direction of each square specimen, being careful not to damage the specimens in any way. All cut specimens must be free from scores or blemishes. A special cutter for cutting the samples may be available from the instrument supplier, or a high-precision cutting board may be used.

10. Procedure

10.1 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).

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

10.2.1 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.

10.3 Turn each of the screws to adjust 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 1: A right hand driving arm attachment is available that automatically stops when the roller contacts the specimen. This device greatly reduces the potential for over or under tightening the test specimen, which could adversely affect the test results.

NOTE 2: It is not necessary for the pendulum to balance at zero with the undeflected specimen in place. Curvature of the specimen may result in a difference between the left and right readings which are 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, but include mention of this occurrence in the report, as this much curl may make the material useless for its intended purpose.

10.4 *For the basic motor-driven instrument,* switch on the motor to rotate the vertical driving 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 driving disk. Stop the motor, record the scale reading on the fixed annular disk (M) and immediately return the driving disk to zero (see Note 3). Take a similar reading by deflecting the specimen to the right. The bending moment of the specimen is the average of the two readings multiplied by the factor of 0.10 for the instrument range of 0 to 10 Taber stiffness units. Test five specimens cut in each direction. Be sure to smoothly drive the unit to the 15° deflection point. Starting and stopping the motor could cause erroneous results.

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.

10.5 *For the automated instrument,* the operations described in 10.4 are automatically done in sequence after the test is initiated. Scale readings (left and right) are displayed on the instrument readout (see Note 4).

11. Calculation

11.1 *Bending moment*-Calculate the bending moment as the average of the two readings (left and right deflection) multiplied by 0.10, the factor required when the 10 unit compression weight is used.

NOTE 4: For the digital version of the automated instrument, this calculation may be done automatically.

11.1.1 The bending moment is calculated from instrument readings which are in Taber stiffness units. Where SI results are desired, convert the value in stiffness units to millinewton meters by multiplying by 0.098066.

11.2 *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. (The length (m) is equal to 0.01 meters.)

12. Report

12.1 Report the following information:

12.1.1 *Bending Moment:*

12.1.1.1 The average value and the unit of measure (stiffness units or millinewton meters) of the specimen tested from each unit cut in each direction separately, to three significant figures.

12.1.1.2 The number of specimens tested in each direction.

12.1.1.3 The standard deviation for each test unit.

12.1.1.4 The test method used for the test, and that the 10 Unit Compensator Weight (or the 0 to 10 Taber stiffness unit instrument range) was used.

12.2 The resistance to bending calculated from the bending moment (see 11.2), to three significant figures.

13. Precision

13.1 Repeatability and reproducibility are estimates of the maximum difference (at 95% confidence) that should be expected when comparing test results for materials similar to those described below under similar test conditions. These estimates may not be valid for different materials and testing conditions.

13.2 The precision estimates of repeatability and reproducibility are based on data from three different sample materials with 10 specimens per sample. One measurement per specimen for a total of 10 measurements for each sample type. The estimates were obtained using test results, each an average of 10 determinations from an interlaboratory study administered between November 2017 and July 2020, conducted in accordance with TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility". The CTS data reflects 10 replicate determinations done in the machine direction only, not five determinations as suggested in the method. Twenty-two laboratories were included in the 50# text calculations, twenty laboratories were included in the 60# text calculations, and sixteen were included in the 70# text calculations.

Material	Grand Mean	r TAPPI Repeatability	%r Repeatability	R TAPPI Reproducibility	%R Reproducibility
50# Text	2.16	0.113	5.23%	0.529	24.50%
60# Text	4.15	0.188	4.54%	0.956	23.05%
70# Text	4.92	0.345	7.01%	1.281	26.03%

Units: g • cm

14. Keywords

Bending, Paper, Resistance, Stiffness, Bend strength

15. Additional Information

15.1 Effective date of issue: To be assigned.

15.2 Normally the apparatus is operated at 115V and 60 Hz ac. If operated at 115 V and 50 Hz, the turning rate of the driving disk will be 175 ± 20° per minute.

15.3 Related methods: International Organization for Standardization ISO 2493; Technical Association of the Australian and New Zealand Pulp and Paper Industry AS/NZS 1301.431rp; British Standards Institution BSI 3748; Scandinavian Pulp, Paper and Board Testing Committee SCAN P-29.

15.4 Only editorial changes and the addition of Figure 2 were made in the 2008 edition. Minor revisions and editorial changes were made in the 2015 edition to harmonize it with TAPPI T 489. In the 2015 version, two new photographs have been added showing the instrument in the proper set-up for conducting tests in the 0–10 Taber stiffness unit configuration. This version includes minor updates from the 2015 version. The scope was expanded to

describe how the modified configuration magnifies the scale. The bending moment is not read from the instrument scale but calculated according to 11.1. The cantilevered loading length was changed from 50 ± 0.025 mm (1.97 in.) as referenced in TAPPI T 489 to 10 ± 0.025 mm (0.39 in.) which is the loading length used for this method. References to the instrument components were harmonized with the descriptions in section 6 (including vertical driving disk and driving arm attachment). A typographical error was corrected (10 unit compression weight should have been described as a compensating weight). An updated precision statement replaced section 13.

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department. ■