WI 120808.16

T 489

DRAFT NO. 2

DATE April 30, 2013

WORKING GROUP
CHAIRMAN Ann Timberlake

SUBJECT
CATEGORY Physical Properties

RELATED
METHODS See "Additional Information"

Bending resistance (stiffness) of paper and paperboard (Taber-type tester in basic configuration) (Revision of T 489 om-08)

(underscores and strikeouts indicate changes from Draft 1)

1. Scope

1.1 This test method covers a procedure used to measure the resistance to bending of paper and paperboard.

1.2 This test method 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 50 mm (1.97 in.) away from the clamp. The resistance to bending is calculated from the bending moment.

1.3 TAPPI T 566 "Bending Resistance (Stiffness) of Paper (Taber-Type Tester in 0 to 10 Taber Stiffness Unit Configuration)" 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, highly flexible, or both.

1.4 Test results obtained using modifications of the basic Taber-type instrument such as that described in

TAPPI T 566 "Bending Resistance (Stiffness) of Paper (Taber-Type Tester in 0 to 10 Taber Stiffness Unit Configuration)" 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.

1.5 Other procedures for measuring bending resistance include TAPPI T 535 "Stiffness of Paperboard (Resonance Length Method)" and TAPPI T 543 "Bending Resistance (Stiffness) of Paper (Gurley-Type Stiffness Tester)." The latter method has been classified as Classical.

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 read from the instrument scale.

2.2 The resistance to bending is calculated from the bending moment.

3. Significance

3.1 A physical characteristic of paperboard which differentiates it from paper is its greater flexural rigidity, commonly called stiffness.

3.2 For most of its uses, the economic value of paperboard depends upon its bending resistance (stiffness), and because this property is closely related to the amount of fiber in the board and hence to its cost, a quantitative measurement is of considerable interest to both producer and user. Bending resistance (stiffness) of paper relates to a number of end use applications, including wrapping, printing, etc.

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 566 "Bending Resistance (Stiffness) of Paper (Taber-Type Tester in 0 to 10 Taber Stiffness Unit Configuration)."

5. Definitions

5.1 *Bending moment* − the work 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 *Stiffness tester*. Any of the instrument variations described 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.

6.1.1.1 A pendulum supported by anti-friction bearings, carries a vise 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, 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 coinciding with the center line of the vise jaws and the weight stud is engraved at the upper end of the pendulum.

6.1.1.2 A vertical disk, driven on the same axis as the pendulum by a driving mechanism at a constant rate of 210 ± 20° per minute. It carries two driving arm attachments 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 crank driving mechanism. The driving arms have rollers that are adjustable to accommodate specimens of different thicknesses. On the periphery of the upper part of the disk are a marked line, coinciding with the center line between the driving rollers and the axis, and two reference lines, engraved on the periphery of the disk at angular distance of 7.5° and 15° on both sides of the center mark

6.1.1.3 Located around the periphery of the disk is a fixed annular disk 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. This scale indicates 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 for the pendulum, to give a maximum bending moment of 5000 g-cm (490 mN • m).

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

6.1.2.1 Devices are available that may be retrofitted to the basic instrument for automatically determining and recording the scale readings. Results are displayed on a digital readout device. In addition, the retrofitted unit may

[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.

provide a signal output suitable for transmission to a stand-alone printer or an integrated acquisition system.

Fig. 1. Stiffness instrument

6.1.2.2 Totally automated versions, incorporating the components described in 6.1.2., and in addition automatically controlling the entire sequence of operations, are also available.

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. Set the loading disk at zero and place a chosen weight 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 vise to meet on the center line of the pendulum and adjust the legs of the instrument so that the engraved mark coincides ~~markcoincides~~ with zero on the scale. 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 vendor 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 rotating disk 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.)

6.3 *Calibration*

6.3.1 Calibrate the instrument and check the accuracy of the apparatus at regular intervals. The method of calibration depends on the type of instrument and shall be done following manufacturer's instructions for the instrument used. Steel spring 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.

7. Sampling

7.1 If a lot of paper is being tested to determine if it meets specification, obtain a sample of the paperboard or paper 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 test specimen 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, 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.

10. Procedure

10.1 Place a conditioned test specimen in the vise with one end approximately level with its top edge and the other end between the rollers.

10.2 With the two clamping screws of the vise, 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.

NOTE 1: At the present time, use of calibration steel test pieces 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.

10.3 Turn each of the screws for adjusting the rollers 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, use the appropriate set of rollers for the thickness of the board to be tested.

NOTE 3: 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 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 loading disk to the left and thus deflect the specimen until the engraved mark on the pendulum is aligned with the 15° mark on the loading disk. Stop the motor, record the scale reading on the fixed annular disk and immediately return the loading disk to zero (see Note 3). Take a similar reading by deflecting the specimen to the right. The stiffness of the specimen is the average of the two readings multiplied by the factor required for the instrument range weight used (see manufacturer's instructions). Test five specimens cut in each direction.

NOTE 4: 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.

10.5 For the 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 as described in Section 10.4.

10.6 *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.

10.7 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 used, state this clearly in the report.

11. Calculation

11.1 *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 that was used during the test (see manufacturer's instructions).

11.1.1 The bending moment is calculated from instrument readings which are in 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. [Length (m) = 0.050 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 the weight (or instrument range) used for the test.

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

13. Precision

The following estimates of repeatability and reproducibility, calculated as the percentage coefficient of variation, were determined in an interlaboratory study using CTS data from 19 testing rounds for the 10 to 100 g • cm range and 10 testing rounds for the 300 to 500 g • cm range. The repeatability and reproducibility are based on 10.

13.1 For the 10 to 100 g • cm scale;

13.1.1 Repeatability = 3% to 7%; mean of 5.5%

13.1.2 Reproducibility = 5% to 11%; mean of 8.0%

13.2 For the 300 to 500 g • cm:

13.2.1 Repeatability = 4% to 7%; mean of 5.8%

13.2.2 Reproducibility = 5% to 8%; mean of 7.0%

14. Keywords

Bending, Paper, Paperboard, Resistance to bending, Stiffness, Taber stiffness

15. Additional information

15.1 Effective date of issue: to be assigned.

15.2 The previous version of this method, TAPPI T 489 om-99, had minor revisions to harmonize it with the new test method TAPPI T 566 using the Taber-type stiffness tester in the 0 to 10 Taber stiffness unit configuration. In this 2008 version, a new photograph of the automated equipment has been added, and references to the hand-cranked instrument have been removed (none are known to be in use). The only changes in the 2013 edition were typrographical corrections.

15.3 Normally the apparatus is operated at 115 V 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.

15.4 Related methods: International Organization for Standardization ISO 2493; Technical Association of the Australian and New Zealand Pulp and Paper Industry APPITA P431; British Standards Institution BSI 3748; Scandinavian Pulp, Paper and Board Testing Committee SCAN P-29; PAPTAC ~~PAPATAC~~ Standards D.28P.

References

Verseput, H. W., "Precision of the Taber Stiffness Test," *Tappi* **52**(6): 1136 (1969).

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

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T 489

DRAFT NO. 1

DATE November 13, 2012

WORKING GROUP
CHAIRMAN to be determined

SUBJECT
CATEGORY Physical Properties

RELATED
METHODS See "Additional Information"

Bending resistance (stiffness) of paper and paperboard (Taber-type tester in basic configuration) (Five-year review of T 489 om-08)

1. Scope

1.1 This test method covers a procedure used to measure the resistance to bending of paper and paperboard.

1.2 This test method 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 50 mm (1.97 in.) away from the clamp. The resistance to bending is calculated from the bending moment.

1.3 TAPPI T 566 "Bending Resistance (Stiffness) of Paper (Taber-Type Tester in 0 to 10 Taber Stiffness Unit Configuration)" 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, highly flexible, or both.

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3.1 A physical characteristic of paperboard which differentiates it from paper is its greater flexural rigidity, commonly called stiffness.

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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 566 "Bending Resistance (Stiffness) of Paper (Taber-Type Tester in 0 to 10 Taber Stiffness Unit Configuration)."

5. Definitions

5.1 *Bending moment* − the work 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 *Stiffness tester*. Any of the instrument variations described 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.

6.1.1.1 A pendulum supported by anti-friction bearings, carries a vise 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, 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 coinciding with the center line of the vise jaws and the weight stud is engraved at the upper end of the pendulum.

6.1.1.2 A vertical disk, driven on the same axis as the pendulum by a driving mechanism at a constant rate of 210 ± 20° per minute. It carries two driving arm attachments 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 crank driving mechanism. The driving arms have rollers that are adjustable to accommodate specimens of different thicknesses. On the periphery of the upper part of the disk are a marked line, coinciding with the center line between the driving rollers and the axis, and two reference lines, engraved on the periphery of the disk at angular distance of 7.5° and 15° on both sides of the center mark

6.1.1.3 Located around the periphery of the disk is a fixed annular disk 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. This scale indicates 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 for the pendulum, to give a maximum bending moment of 5000 g-cm (490 mN • m).

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

6.1.2.1 Devices are available that may be retrofitted to the basic instrument for automatically determining and recording the scale readings. 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.

[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. Stiffness instrument

6.1.2.2 Totally automated versions, incorporating the components described in 6.1.2., and in addition automatically controlling the entire sequence of operations, are also available.

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. Set the loading disk at zero and place a chosen weight 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 vise to meet on the center line of the pendulum and adjust the legs of the instrument so that the engraved markcoincides with zero on the scale. 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 vendor 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 rotating disk 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.)

6.3 *Calibration*

6.3.1 Calibrate the instrument and check the accuracy of the apparatus at regular intervals. The method of calibration depends on the type of instrument and shall be done following manufacturer's instructions for the instrument used. Steel spring 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.

7. Sampling

7.1 If a lot of paper is being tested to determine if it meets specification, obtain a sample of the paperboard or paper 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 test specimen 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, 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.

10. Procedure

10.1 Place a conditioned test specimen in the vise with one end approximately level with its top edge and the other end between the rollers.

10.2 With the two clamping screws of the vise, 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.

NOTE 1: At the present time, use of calibration steel test pieces 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.

10.3 Turn each of the screws for adjusting the rollers 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, use the appropriate set of rollers for the thickness of the board to be tested.

NOTE 3: 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 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 loading disk to the left and thus deflect the specimen until the engraved mark on the pendulum is aligned with the 15° mark on the loading disk. Stop the motor, record the scale reading on the fixed annular disk and immediately return the loading disk to zero (see Note 3). Take a similar reading by deflecting the specimen to the right. The stiffness of the specimen is the average of the two readings multiplied by the factor required for the instrument range weight used (see manufacturer's instructions). Test five specimens cut in each direction.

NOTE 4: 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.

10.5 For the 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 as described in Section 10.4.

10.6 *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.

10.7 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 used, state this clearly in the report.

11. Calculation

11.1 *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 that was used during the test (see manufacturer's instructions).

11.1.1 The bending moment is calculated from instrument readings which are in 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. [Length (m) = 0.050 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 the weight (or instrument range) used for the test.

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

13. Precision

The following estimates of repeatability and reproducibility, calculated as the percentage coefficient of variation, were determined in an interlaboratory study using CTS data from 19 testing rounds for the 10 to 100 g • cm range and 10 testing rounds for the 300 to 500 g • cm range. The repeatability and reproducibility are based on 10.

13.1 For the 10 to 100 g • cm scale;

13.1.1 Repeatability = 3% to 7%; mean of 5.5%

13.1.2 Reproducibility = 5% to 11%; mean of 8.0%

13.2 For the 300 to 500 g • cm:

13.2.1 Repeatability = 4% to 7%; mean of 5.8%

13.2.2 Reproducibility = 5% to 8%; mean of 7.0%

14. Keywords

Bending, Paper, Paperboard, Resistance to bending, Stiffness, Taber stiffness

15. Additional information

15.1 Effective date of issue: to be assigned.

15.2 The previous version of this method, TAPPI T 489 om-99, had minor revisions to harmonize it with the new test method TAPPI T 566 using the Taber-type stiffness tester in the 0 to 10 Taber stiffness unit configuration. In this 2008 version, a new photograph of the automated equipment has been added, and references to the hand-cranked instrument have been removed (none are known to be in use).

15.3 Normally the apparatus is operated at 115 V 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.

15.4 Related methods: International Organization for Standardization ISO 2493; Technical Association of the Australian and New Zealand Pulp and Paper Industry APPITA P431; British Standards Institution BSI 3748; Scandinavian Pulp, Paper and Board Testing Committee SCAN P-29; PAPATAC Standards D.28P.

References

Verseput, H. W., "Precision of the Taber Stiffness Test," *Tappi* **52**(6): 1136 (1969).

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