WI 180808.03

T 423

DRAFT NO. 3 SARG

DATE October 5, 2021

WORKING GROUP CHAIRMAN Dennis Crawshaw

SUBJECT CATEGORY Physical Properties

RELATED METHODS See "Additional Information"

Folding endurance of paper (Schopper type tester)

(Proposed Reaffirmation of T 423 cm-07 as a classical method)

(No changes were made from the previous draft. Standard reaffirmed.)

1. Scope

1.1 This method describes the use of the Schopper type of folding apparatus. It is suitable for papers having a thickness of 0.25 mm (0.010 in.) or less.

1.2 The procedure for the MIT type apparatus, which may be used for papers of any thickness, is described in TAPPI T 511 "Folding Endurance of Paper (MIT Tester)."

2. Significance

Folding endurance tests have been used for the estimation of the suitability of paper in use to withstand repeated bending, folding, and creasing.

3. Apparatus

3.1 *Folding tester* (Fig. 1 in the Appendix), consisting of the following:

3.1.1 Two horizontally opposed and movable *clamping jaws*, which hold a specimen 100 mm (4 in.) long under variable tension during the folding cycle, while a slotted folding blade, sliding back and forth between four

creasing rollers, folds the paper at 105-125 double folds per minute. The clamps are supported from below on rollers and, while in motion, are freely suspended between tension springs. The folding blade is 0.50 ± 0.0125 mm (0.020 ± 0.0005 in.) thick, with a vertical folding slot 0.50 ± 0.0125 mm (0.020 ± 0.0005 in.) wide, the slot extending somewhat above and below the normal position of the test specimen. The vertical edges of the slot are cylindrical with radius equal to half the thickness of the blade. The four creasing rollers, each 6 mm (approximately ¼ in.) diameter and 18 mm (approximately ¾ in.) long, are arranged symmetrically about the midposition of the folding slot, and are provided with antifriction or jeweled bearings.

3.1.2 *Counter*, to register the number of double folds and to stop the instrument when the specimen breaks.

3.2 *Cutter*, to provide test strips, 15.0 ± 0.1 mm (0.590 ± 0.004 in.) wide, and with clean edges.

4. Adjustment and calibration

4.1 Test the clamps as follows: Insert a specimen in place and alternately apply and release the tension a number of times. Then, with tension released, note whether the specimen remains smooth and straight as originally inserted. Buckling or waviness indicates a faulty clamp which has allowed the specimen to slip.

4.2 Inspect the supporting rollers for worn surfaces and for bearing friction, and correct if necessary. Adjust the rollers so that they do not bind against the clamps in any position. With a feeler gage, check the four creasing rollers for parallelism and clearance. Also make sure that the two edges of the folding slot are parallel with each other and with the creasing rollers. The distance between the folding blade and the two creasing rollers on each side of it is required to be 0.38 ± 0.05 mm (0.015 ± 0.002 in.), and the width between the rollers of the space occupied by the unbent specimen should be approximately 0.5 mm (0.02 in.). As a final test of alignment, fold a specimen somewhat short of failure and inspect it for uniformity of wear along the crease. If the specimen seems weaker at one end of the crease than at the other, and the ends of the strip are satisfactorily clamped, this indicates faulty alignment of the rollers or the folding slot and will lead to low folding results.

4.3 Adjust the tension springs attached to the clamps against dead-weight loads, so that the tension on the specimen during a test is 7.60 ± 0.1 N (780 ± 10 gf) when the clamps are farthest apart (when the specimen is straight and free), and 9.81 ± 0.1 N (1000 ± 10 gf) when they are nearest together. The adjustments are preferably made *in situ* with the aid of a calibrating device (*1*), as described (Fig. 1) in the Appendix.

NOTE 1: As stated in Section A.3.2, the minimum tension (7.60 ± 0.1 N) is the most important value. If the difference between the maximum and minimum tension is not equal to the desirable 2.21 n., then the minimum tension should be adjusted to the 7.60 N value and the maximum rechecked. If the maximum tension is not within 0.5 N of the specified 9.81 N then the springs should be replaced.

4.4 Adjust and calibrate the instrument at least once a month if it is in continual use or immediately before a test.

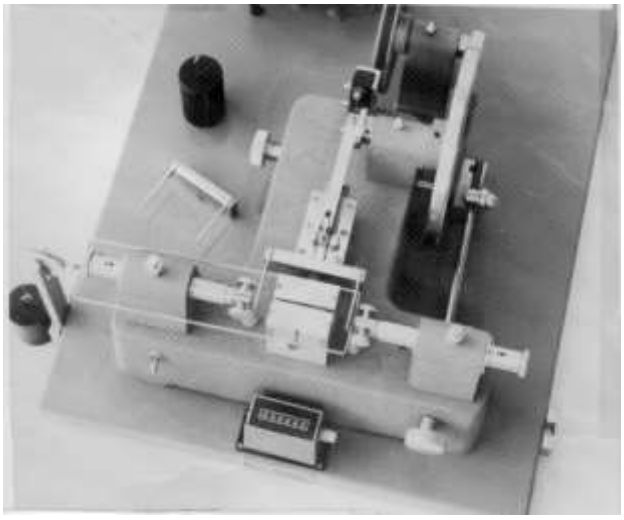

Fig. 1. Schopper-type tester.

5. Sampling and test specimens

5.1 Obtain a sample of the paper in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product." From each test unit obtain 10 specimens, cut in each principal direction of the paper, having a width of 15.0 ± 0.1 mm (0.590 ± 0.004 in.) and a length of 100 mm (4 in.). Select specimens that are free from wrinkles or blemishes not inherent in the paper and be sure that the area where the folding is to take place does not contain any portion of a watermark and appears to be of average opacity.

5.2 Handle each specimen by an end and do not touch it with the hands in the region in which it is to be folded.

6. Procedure

6.1 Precondition, condition, and test the paper in accordance with TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products."

NOTE 2: Because of the extreme sensitivity of this test to the moisture content of the specimen, it is important that the moisture equilibrium be approached from a drier state as specified in T 402.

6.2 Lock the vertical slot of the reciprocating blade is in its central position and release tension on the jaws. Without touching the center of the specimen, place it in the slot and fasten the ends firmly and squarely in the jaws so that the surface of the specimen lies wholly within one plane. Apply the tension and fold the specimen until it breaks. Record the number of double folds made before fracture.

7. Report

7.1 Folding endurance is defined as the logarithm (to the base 10) of the number of double folds.

7.1.1 For each test unit record the number of double folds for the machine and cross directions. Convert the raw data to the logarithm (base 10) by using common log tables. Calculate the mean of the logs and report as $\log_{10}$ Schopper type folding endurance to three significant figures. Include the number of specimens tested and the maximum and minimum $\log_{10}$ of the fold number obtained in each direction.

7.2 *Alternative report*. For each test unit, report the average test result for the machine and cross directions of the paper separately, as Schopper type tester folding number (double folds), to two significant figures. Include the number of specimens tested and the maximum and the minimum values obtained in each direction, and the temperature and relative humidity under which sample was tested.

7.3 Tests made on strips having their lengths in the machine direction are designated as "machine direction," and, correspondingly, those having their lengths at right angles to the machine direction are designated as "cross direction."

8. Precision

8.1 Repeatability = 15%;

8.2 Reproducibility = 40%; according to the definition of these terms in TAPPI T 1206 "Precision Statement for Test Methods."

NOTE 3: Precision statement is based on folding number.

NOTE 4: Folding endurance numbers are very susceptible to small errors in the adjustment and calibration of the instrument and in the relative humidity of the test room. Limits as much as 2½ times those shown may be expected if the instructions of this method are not followed meticulously (*2-5*).

9. Keywords

Paper, Fold, Folding endurance, Folding number

10. Additional information

10.1 Effective date of issue: to be assigned.

10.2 The 1978 revision specified the minimum and maximum tension in SI units, with tolerances, and also gave a tolerance in the distance between the folding blade and the two creasing rollers. A statement of significance was also added.

10.3 The use of a suction fan to cool the folding blade has been found useful in minimizing variations in

results.

10.4 Related methods: British BS 4419 "Methods for Determination of Folding Endurance of Paper;" German, DIN VZ and PCIV/12; French, AFNOR Q03-001; ISO 5626 "Determination of Folding Endurance."

10.5 This method, formerly T 432 om-89, has been reclassified as a Classical Method. Such procedures are no longer in common use or have been superceded by advanced technology; they are technically sound, have a history of use, and contain a body of literature references that make their preservation valuable.

References

1. Carson, F. T., and Snyder, L. W., "Calibration and Adjustments of Schopper Folding Tester," Bureau of Standards Technologic Paper No. 375 (1929).
2. Brecht, W., and Korner, L., "The Accuracy in Testing of Paper Properties," *Das Papier* **5**: 155 (1951).
3. Reitz, L. K., and Sillay, F. J., "Application of Statistical Methods to Paper Testing Procedures," *Paper Trade J.* **126** (17): 54 (1948).
4. Kahlson, T., and Martensson, B., "The Reason for Variations in Folding Endurance Values," *Paperi ja Puu* **46** (10): 581 (1964).
5. Brecht, W., and Wesp, A., "A New Method for Testing Folding Strength," *Das Papier* **6**: 443 (1952).

Appendix

Instructions for use of the calibrating device

A.1 *Apparatus* (see Fig. 1).

A.1.1 *Wire-pulling frame*

A.1.2 *Blocks*, two, with protruding limit guides (one for 1000 gf extension, the other for 780 gf extension).

A.1.3 *Upright*, with free-turning pulley.

A.1.4 *Weights*, 1000-g and 780-g.

A.1.5 *Brackets*, for use with the upright.

A.2 *Mounting*

A.2.1 Screw the upright brackets to each side of the wooden base so that when the upright with the free-turning pulley is placed in the bracket cutout, the center of the pulley is exactly in line with the center of the barrels, the center of the jaws, the center of the bearing block, and the movement of the jaws.

A.2.2 Place the wire-pulling frame over one of the barrel assemblies and central bearing blocks. Grip the flat metal tang of the frame in the jaw of the other assembly so that the top of the tang is flush with the top of the jaw.

A.2.3 With the flywheel of the instrument in its locked position, place the block with protruding limit guides on the sliding mechanism, so that the sliding arm fits into the cutout of the block and that the protruding limit guides at the top of the block extend out over the wire-pulling frame. Insert the upright with free-turning pulley in its bracket.

Hook the string attached to the weight to the center of the end section of the wire-pulling frame and pass the string over the pulley to hold the weight vertically.

A.3 *Operation*

A.3.1 There are two sets of limit guides: one to indicate the relaxed position of the jaws and the second fixed to indicate the extended limit of the jaws. With the first set in position, pull the barrel mechanism to its outward position and gently release the suspended 1000-g weight. When the spring of the jaw is correctly calibrated, the jaw will then barely touch the edge of the protruding limit guide. If the jaw does not reach the protruding limit guide or if it touches and is stopped by it, loosen the small Allen setscrew on the rear side of the barrel and turn the knurled knob one way or the other, until contact is just barely made.

A.3.2 Next, remove the 1000-g weight and place the limit guide for the relaxed position. Apply the 780-g weight; the jaw should then barely touch the extended limit guide. By turning the knob on the barrel assembly, a delicate adjustment should result in an agreement between the spring tension and the extension of the jaws in both the relaxed and the extended positions.

NOTE 5: The adjustment made with the 780-g weight is more important than with the 1000-g weight.

A.3.3 Apply the same procedure for the opposite jaw after reversing the position of the wire-pulling frame and the upright with the free-turning pulley.

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