WI 220808.07

T 495

BALLOT NO. 2 SARG

DRAFT NO. 01

DATE 06/01/2023

WORKING GROUP CHAIR To Be Determined

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 Number of Paperboard

Proposed WITHDRAWAL of Classical Method T 495 cm-13

1. Scope

This test is used to evaluate the bending quality of both coated and uncoated paperboard from 0.4 to 1.0 mm (0.016 to 0.040 in.) in thickness made on fourdrinier or multi-ply cylinder machines.

2. Summary

2.1 In this test, the scoring and folding of a sample of paperboard is evaluated by scoring the board using different combinations of rule and die widths and die penetration depths and then folding the board along the score line. Using rule and die dimensions specified for the caliper of the sample being tested, a bending number and/or a die to caliper ratio can be determined. The test results are related to the ability of the paperboard to be scored and folded satisfactorily.

2.2 The bending quality of paperboard depends on both the elastic properties of the paperboard and the proper selection of the rule and die width and depth of die penetration used to score the board. In order to convert paperboard into folding cartons and other shapes, the board is scored and then folded on the score line. During scoring, the board is partially delaminated and it is permanently deformed in the shape of a shallow "U." During folding, the top or outer layer of the board is put under tension while the other layers deform into a bead on the inside of the fold. In a "good" fold, the top or outer layer bends without cracking, and the inside of the fold is wide enough to accommodate the bead without collapsing.

2.3 In this test, for cross-machine direction (CD) scores (scores parallel to the cross-machine direction), the width of the female die is varied for each male rule used in the bending tester. For machine direction (MD) scores (scoring parallel to the machine direction), the depth of penetration of the rule into the die is also varied. MD scores generally require greater penetration than CD scores because paperboard generally has lower elasticity across a fold which is parallel to the machine direction.

3. Significance

3.1 The test results are used to assess the suitability of paperboard for conversion into folded cartons without score line rupture of the outer surface. The test can be used to guide the choice of appropriate scoring parameters for converting operations by predicting the best die and rule combination and penetration depth for making satisfactory scores on a given board. It can also be used to determine whether the scoring conditions or the board composition is the cause of score cracking.

3.2 The bending quality in the cross-machine direction shows the best agreement with actual performance *(1).* Scoring in the machine direction is accurately predictable using dies designed for that purpose *(2, 3).*

3.3 In comparing paperboards of different composition but similar caliper, the lower the die to caliper ratio that gives a satisfactory fold, the better the bending quality of the board (*4*).

4. Definition

Bending number, a composite number that describes the position of the male rule and female die within the scoring apparatus that together produce the narrowest and least penetrating score mark that results in a satisfactory fold when the scored paperboard is folded 180º.

5. Apparatus

5.1 *Applicator,* a wire wound bar such as a No. 12 or No. 14 Meyer rod or equivalent means of applying a thin uniform film of fluid ink.

5.2 *Ironing bar,* 19 mm (3/4 in.) diameter by 152 mm (6 in.) long polished drill rod.

5.3 *Humidity cabinet*, or room, to condition the test specimens at 32.5 ± 2.5% R.H. at a temperature of 23.0 ± 2.0ºC (73.4 ± 3.6ºF).

5.4 *Micrometer*, for measuring paperboard thickness in accordance with T 411 "Thickness (Caliper) of Paper, Paperboard, and Combined Board."

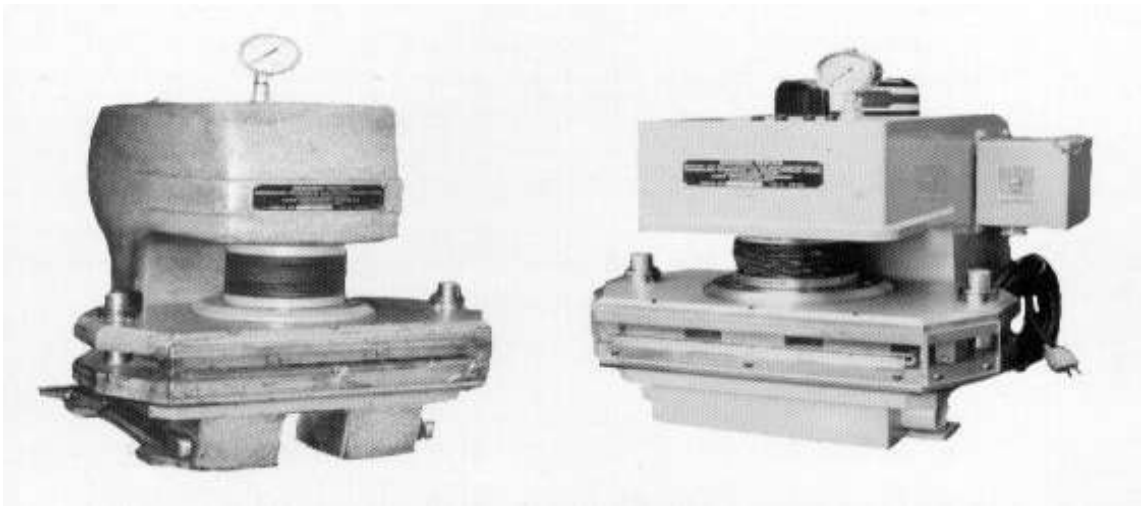

Fig. 1. Bending tester

5.5 *Bending tester*[1] (see Fig. 1) consisting of:

5.5.1 *Scoring device*, a hydraulic press having platens, equipped with precisely dimensioned male and female scoring dies. The platens have guide pins mounted vertically through bushings to maintain their parallelism and alignment. The male and female die parts are divided into six cooperating sections with each section equipped to test one range of board caliper in each principal grain direction. Each section is 50 mm (2 in.) wide, with 32 mm (1.25 in.) spacing between the adjacent test positions. Table 1 gives dimensions, in mils and millimeters, of the elements of each section for bending quality evaluation in each principal direction.

5.5.2 *Stop*, mounted at the rear of the lower die, extending across its six sections to provide for the proper positioning of the test specimens. A guard of transparent plastic mounted on the lower platen is provided across the front of the dies and is slotted to permit the insertion of the test specimen. Each section is identified for specimen testing in either MD or CD.

[1]Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the set of TAPPI Test Methods, or may be available from the TAPPI Quality and Standards Department.

Table 1. Dimensions of dies

Cross direction scores							*Machine direction scores*						
Test Position	*Max. board calliper,*		*Female die width,*		*Rule Penetration*		*Test Position*	*Max. board caplier,*		*Female die width,*		*Rule penetration,*	
	mils	*(mm)*	*mils*	*(mm)*	*mils*	*(mm)*		*mils*	*(mm)*	*mils*	*(mm)*	*mils*	*(mm)*
2-	point male rule section [28 mils (0.70 mm) rule width]												
2-1	15	(0.38)	54	(1.37)	0	(0)	2A-1	17	(0.43)	54	(1.37)	0	(0)
2-2	18	(0.46)	62	(1.57)	0	(0)	2A-2	17	(0.43)	54	(1.37)	5	(0.13)
2-3	20	(0.51)	70	(1.78)	0	(0)	2A-3	17	(0.43)	54	(1.37)	10	(0.25)
2-4	22	(0.56)	78	(1.98)	0	(0)	2B-1	21	(0.53)	64	(1.63)	0	(0)
2-5	24	(0.61)	86	(2.18)	0	(0)	2B-2	21	(0.53)	64	(1.63)	5	(0.13)
2-6	26	(0.66)	94	(2.39	0	(0)	2B-3	21	(0.53)	64	(1.63)	10	(0.25)
3-	point male rule section [42 mils (1.05 mm) rule width]												
3-1	22	(0.56)	78	(1.98)	0	(0)	3A-1	25	(0.64)	84	(2.13)	0	(0)
3-2	24	(0.61)	86	(2.18)	0	(0)	3A-2	25	(0.64)	84	(2.13)	5	(0.13)
3-3	27	(0.69)	94	(2.39)	0	(0)	3A-3	25	(0.64)	84	(2.13)	10	(0.25)
3-4	29	(0.74)	102	(2.59)	0	(0)	3B-1	29	(0.74)	92	(2.34)	0	(0)
3-5	31	(0.79)	110	(2.79)	0	(0)	3B-2	29	(0.74)	92	(2.34)	5	(0.13)
3-6	34	(0.86)	118	(3.00)	0	(0)	3B-3	29	(0.74)	92	(2.34)	10	(0.25)
4-	point male rule section [56 mils (1.40 mm) rule width]												
4-1	29	(0.74)	102	(2.59)	5	(0.13)	4A-1	33	(0.84)	112	(2.84)	5	(0.13)
4-2	31	(0.79)	110	(2.79)	5	(0.13)	4A-2	33	(0.84)	112	(2.84)	10	(0.25)
4-3	34	(0.86)	118	(3.00)	5	(0.13)	4A-3	33	(0.84)	112	(2.84)	15	(0.38)
4-4	36	(0.91)	126	(3.20)	5	(0.13)	4B-1	38	(0.97)	120	(3.05)	5	(0.13)
4-5	38	(0.97)	134	(3.40)	5	(0.13)	4B-2	38	(0.97)	120	(3.05)	10	(0.25)
4-6	40	(1.02)	142	(3.61)	5	(0.13)	4B-3	38	(0.97)	120	(3.05)	15	(0.38)

5.5.3 *Hydraulic ram*, capable of delivering a force of at least 6.7 kN (1500 lbf), which brings the male and female dies together. All six scores in each section are impressed in the specimen simultaneously. The upper platen carries the male dies. Dual activating switches are mounted on each side of the instrument so that both hands must be outside before the platens can close. Positive replaceable stops are mounted on the outer edge of the platen to insure that the penetration depth is no greater than that specified when making the scores.

6. Calibration

6.1 Check the spacing and width of the female and male rules with a feeler gauge and a micrometer at least every six months. Maintain dimensions within 0.025 mm (0.001 in.) of their specification.

6.2 Check that the depth of penetration of the scoring rule into the female die corresponds with figures given in Table 1 or the clearance of the male with the top of the female die is such that no more than a 0.025 mm (0.001 in.) feeler gauge may be inserted without distortion between the elements, with the dies closed on those sections. Where penetration depth is 0.13 mm (0.005 in.) or 0.25 mm (0.010 in.), cut a shim of aluminum or brass of the exact thickness of the depth of the female die, less the penetration specified, and of the same score width and length. To the ends of the shim, with an adhesive, tack a piece of 0.025 mm (0.001 in.) carbon paper of the same width and length, with the carbon side adjacent to the metal. Insert this combination in the female die and close the dies. If an impression is not made onthe metal by the die closure, the male rule requires shimming. If more than a trace of impression appears on the shim, determine the amount of rule relief by using thinner shims. In either case adjust the correct penetration by changing the height of the male rule so as to obtain just a thin impression line of the carbon-paper-covered metal shim. Check the hydraulic pressure daily to see that the ram delivers a 6.7 kN (1500 lbf) force and that the stops are bottoming positively. Close the needle valve to protect the gauge when not being used for a check.

7. Materials

Ink, blue or black pigmented non-aqueous gravure or flexographic ink, for coating the surface of the board specimen prior to scoring. For many materials, a dark, indelible felt tip marker is satisfactory. Scorelines on inked surfaces show folding failure more readily than those on uninked surfaces.

8. Sampling and test specimens

8.1 If a lot of paper is being tested, obtain samples in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product." From each test unit cut five specimens, 50 x 300 mm (2 x 12 in.), with the grain in the direction of the test, i.e., 50 x 300 mm (2 x 12 in.) for CD, and 300 x 50 mm (12 x 2 in.) for MD evaluation.

8.2 For quality control, take three specimens across the width of the board machine.

9. Procedure

9.1 Determine the caliper of each test specimen in accordance with T 411 "Thickness (Caliper) of Paper, Paperboard, and Combined Board."

9.2 With the applicator, apply a thin film of dark ink to the outer surface of each specimen. Alternate Procedure: For control testing of many materials, a satisfactory result can be obtained by eliminating this step and using a dark, indelible (non-aqueous) felt tip marker to darken the outer surface after the score has been made (see 9.5), but before the board is folded (see 9.6).

9.3 Condition the specimens at 32.5 ± 2.5% R.H. for at least 24 hours in the case of a referee test, or for at least 20 min. in the case of a control test. The conditioning chamber should be located in a testing room maintained at the standard conditioning atmosphere in accordance with T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp, Handsheets, and Related Products."

NOTE 1: The purpose of the special conditioning is to simulate the driest converting environment likely to be encountered in commercial practice. Bending quality improves at high relative humidities and deteriorates at very low relative humidities.

9.4 Perform the tests in a standard testing atmosphere as described in T 402 (50% R.H.). Perform the tests within 2 minutes after removing the test specimens from the conditioning cabinet.

NOTE 2: Unless specimens can be tested within two minutes after removal from the conditioning chamber, place them in a polyethylene bag to prevent undue exposure to the 50% R.H. test atmosphere.

NOTE 3: When comparing paperboard from different lots, if the tests cannot be completed within two minutes, use conditioned specimens selected alternately from different lots.

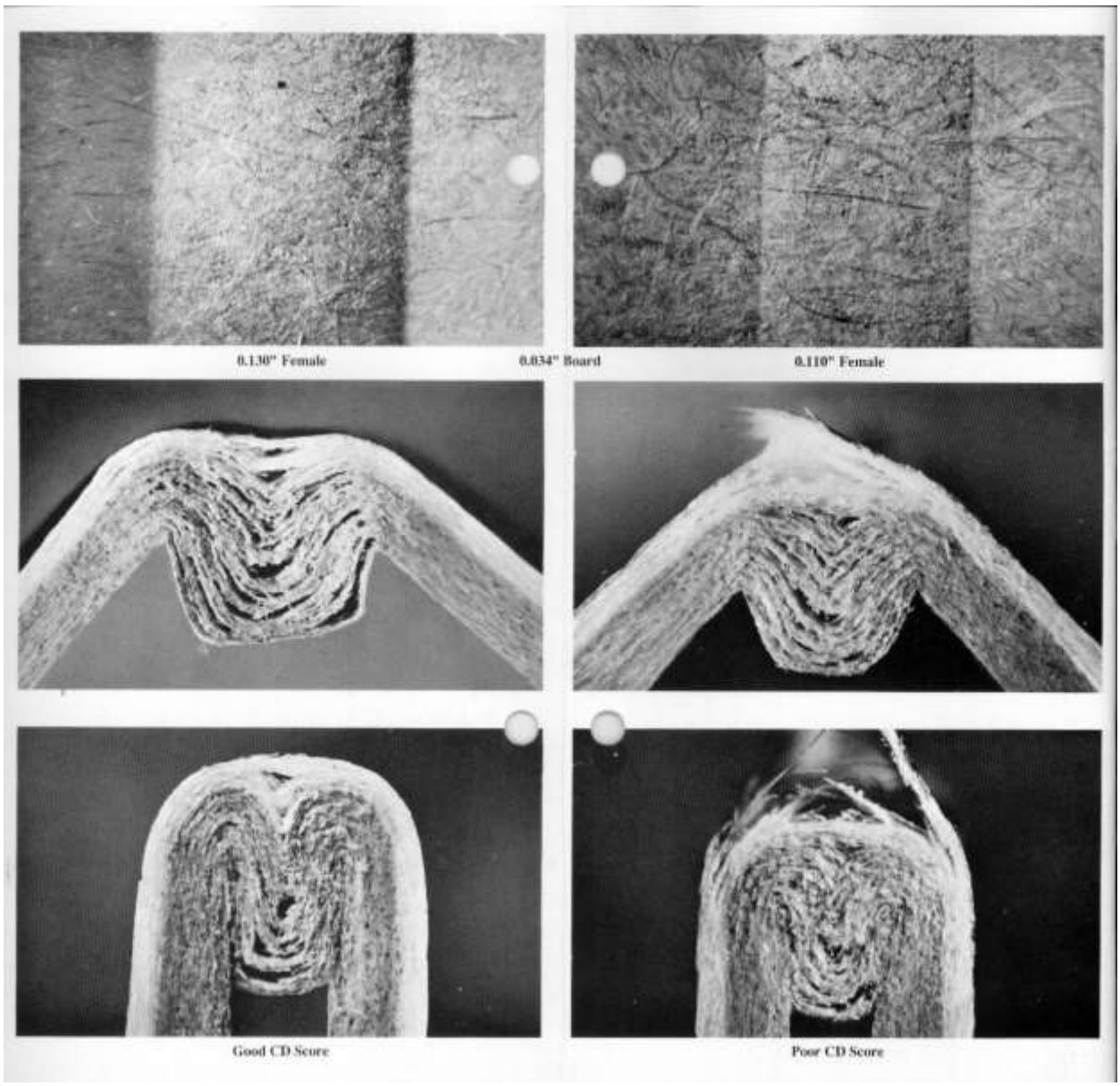

Fig. 2A. Examples of good and poor folding results.

9.5 Place each specimen in the die in the test apparatus appropriate for the specimen's thickness and grain orientation with the male rules adjacent to the inked outer surface. Activate the dual switches. Ensure complete penetration of the rules into the board by observing that the stops make positive contact. If it is found that the dies are not bottoming and proper pressure is being applied, reduce the width of the test specimens.

9.6 Fold each score through 180° enclosing the inner side. Beginning with the narrowest score, press each score with moderate finger pressure then iron across once with the ironing bar using moderate hand pressure. Examine the scores to determine the narrowest score which shows satisfactory folding. See Figure 2 for examples of good and poor folding results.

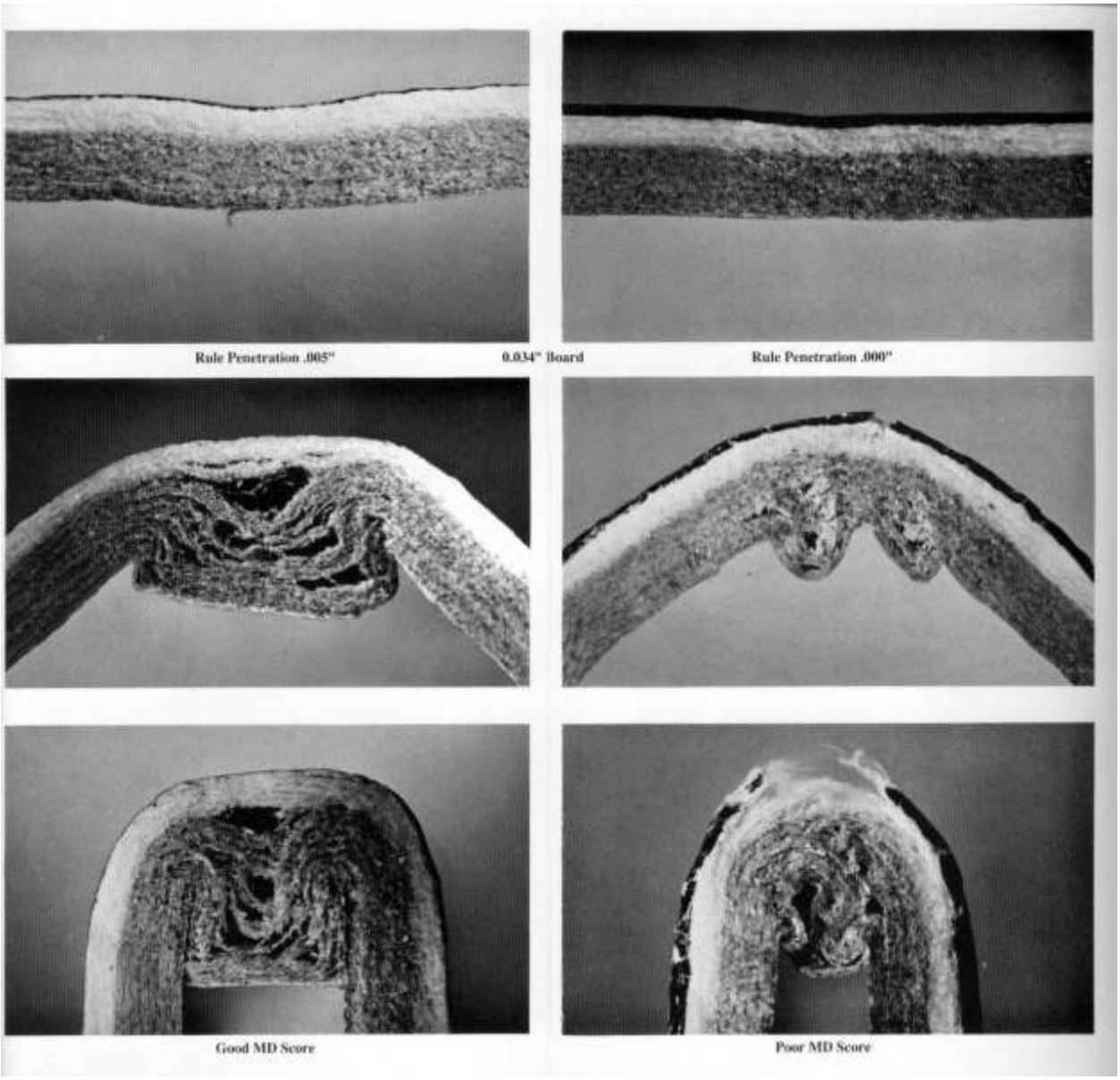

Fig. 2B. Examples of good and poor folding results.

10. Report

10.1 Report the average bending number to the nearest whole number as the rule number followed by the number of the narrowest score without a crack for each of the five specimens followed by the orientation of the fold (MD or CD) in parentheses. For example: For folds parallel to the cross direction, a 0.50 mm (0.020 in.) board which cracks on the second score in the two point rule section but bends without cracking on the third score, would be rated a 2-3 (CD). Similarly, a 0.72 mm (0.029 in.) board that bends satisfactorily on the narrowest score at the four-point rule section but cracks on the widest score of the three-point rule section would be rated 4-1 (CD). Likewise for folds parallelto the machine direction, a 0.42 mm (0.017 in.) board with folds parallel to the MD which cracks in position 3 of the 2A

section but bends without cracking in position 1 of the 2B section, would be rated 2B-1 (MD) and a 0.72 mm board which cracks in position 3 of the 3B section but bends without cracking in position 1 of the 4A section, would be rated 4A-1 (MD).

10.2 *Alternate Report*: For each specimen calculate (to one decimal place) the ratio of the female die width to the specimen caliper for the narrowest die width that produced a satisfactory fold. Express both die width and caliper in the same units. Report the result for a test unit as the average of the ratios for the individual test specimens. For each reported result, indicate the direction of the fold and the penetration depth.

ratio = w/c

w = female die width
c = caliper of test specimen

11. Precision

11.1 *Repeatability*: One bending number (from a round robin conducted by members of the multi-ply industry and evaluated by the Boxboard Research and Development Association.

11.2 *Reproducibility*: Cross direction, 0.5 bending number based upon a round robin involving three boards in calipers of 0.020, 0.026, and 0.030 in., with 10 replications each in several laboratories (exact number unknown). Machine direction, 0.8 bending number based upon a round robin including 16 boards ranging in caliper from 0.014 to 0.036 in., in three laboratories.

11.3 These precision statements were prepared in accordance with TAPPI T 1200 “Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility.”

12. Keywords

Paperboard, Scoring, Folding, Conversion, Bending

13. Additional Information

13.1 Effective date of issue: To Be Assigned

13.2 In this revision, the following information was added: summary section; definition of bending number; alternate means for inking the outer surface of the test specimen; alternate report of results using caliper ratio. The precision statement was rewritten using repeatability data from the 1982 version; the 1988 repeatability data that involved round robin testing was restated as reproducibility. The Additional Information section was expanded to include recent findings from RPTA. Other sections of the text were edited for clarity or to conform to current TAPPI usage.

13.3 This test and the associated equipment was developed by the Boxboard Research and Development Association (BRDA), now known as the Recycled Paperboard Technical Association (RPTA).

13.4 According to RPTA *(4)*, the most critical factor in scoring and bending is provision of adequate space to accommodate the "bead" that forms on the inside of the bend when the board is folded. The RPTA has developed "scoring rules" for selection of rules and dies which provide for a satisfactory bead and reduce the stress on the outer surface of the fold. The width of the female groove should be equal to or slightly less than twice the board caliper plus the thickness of the male rule. Also, for satisfactory performance on CD scores, the ratio of female die width to caliper should be between 3.5 and 4.0. For MD scores, the ratio should be approximately 3.5. Narrower die widths may result in excessive strain on the outer surface, causing it to rupture.

13.5 The die to caliper ratios are helpful in selecting an appropriate rule width. For example, in scoring a 0.022 in. board in the CD, if a 0.028 in. (2 pt) rule is used, the female die must be 0.068 in. to 0.072 in. However, this results in a female die to caliper ratio of 3.2 which is not likely to give a satisfactory CD fold. If a 0.042 in. (3 pt) rule is used instead, the female die width should be 0.082 to 0.086 in. and the ratio would be 3.8, which would be more likely to give a satisfactory fold.

13.6 Any one of the sections shown in Table 1 may be replaced with a 1.5-point (0.52-mm) male rule and corresponding female die section. This combination is applicable for paperboard 0.25 to 0.38 mm (0.010 to 0.015 in.) thick. It is not included in the procedure at present because of a lack of adequate data. Recommended dimensions are shown in Table 2.

Table 2. Recommended dimensions for 1 1/2-point rule [21 mils (0.52 mm) width]

Cross direction scores							*Machine direction scores*						
Test Position	*Board caliper*,*		*Female width,*		*Rule penetration*		*Test Position*	*Board caliper*,*		*Female width,*		*Rule penetration,*	
	mils	*(mm)*	*mils*	*(mm)*	*mils*	*(mm)*		*mils*	*(mm)*	*mils*	*(mm)*	*mils*	*(mm)*
1 1/2-1	Range		39	(0.99)	0	(0)	1 1/2-1	Range		39	(0.99)	5	(0.13)
1 1/2-2	10	(0.0.25	44	(1.12)	0	(0)	1 1/2-2	10	(0.025	44	(1.12)	5	(0.13)
1 1/2-3	to	to	49	(1.24)	0	(0)	1 1/2-3	to	to	49	(1.24)	5	(0.13)
1 1/2-4	15	0.038	54	(1.37)	0	(0)	1 1/2-4	15	0.038	54	(1.37)	5	(0.13)
1 1/2-5	mils	mm)	59	(1.50)	0	(0)	1 1/2-5	mils	mm)	59	(1.50)	5	(0.13)
1 1/2-6			64	(1.63)	0	(0)	1 1/2-6			64	(1.63)	5	(0.13)

Literature cited

1. Lewis, R. L., Eckhart, C. G., and Luey, A. T., "The BRDA Scoreability Tester," *Tappi* **43** (5): 244A (1960).
2. Eckhart, C. G., "Scoreability of Cylinder Paperboard," BRDA Production-Technical Seminar, 1968.
3. Eckhart, C. G., Luey, A. T., and Schulz, R. E., "Scoreability of Paperboard," Proceedings of Paperboard Packaging Council, 1970.
4. Technical Bulletin No.12, Recycled Paperboard Technical Association, 1992.

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