SCAN-P 29:95
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SCANDINAVIAN PULP, PAPER AND BOARD
TESTING COMMITTEE

Papers and boards

Bending resistance

0 Introduction

This SCAN-test Method specifies a procedure, based on the beam principle, for determining the resistance to bending, i.e. the force required to bend a test piece through a certain angle.

The Method replaces SCAN-P 29:84 from which it differs in that a clamping pressure now is recommended and that the free length of the test piece now is specified, which will improve the precision of the results obtained.

The Method is in accordance with ISO 2493 and will give the same results provided the same type of bending resistance measurement principle and clamping pressure are used.

For measurement of the material property *bending stiffness*, ISO 5629 Papers and boards – Determination of bending stiffness – Resonance method, is recommended.

1 Scope

This SCAN-test Method specifies the equipment and the Procedure of determining the bending resistance of papers and boards. The Method does not apply to corrugated board but it may be used for its components. The Method is not applicable to twisted or curled test pieces.

Note 1 – The method of determining bending resistance of laboratory sheets is described in ISO 5270.

The recommended bending angle is 15° and the recommended test span length is 50 mm.

Note 2 – For samples having a low bending resistance, the test span length is reduced to 10 mm. For boards that crack if bent through 15°, half the bending angle, 7,5°, is applied.

2 References

ISO 187	Paper, board and pulps – Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples (EN 20187)
ISO 536	Paper and board – Determination of grammage (EN ISO 536)
SCAN-P 9	Papers and boards – Identification of machine and cross direction
SCAN-P 10	Papers and boards – Identification of wire side

Note – SCAN-test has withdrawn a number of test methods and refers instead to the corresponding ISO and/or EN Standards.

3 Definitions

For the purpose of this Method the following definitions apply:

3.1 *Bending resistance, F_B* – The force required to bend a rectangular test piece which is clamped at one end, the force being measured under conditions specified in this Method.

The bending resistance is considered to be measured in the direction (machine or cross) of the test piece which is perpendicular to the edges of the clamp.
The bending resistance is considered to be measured towards the side (top side or wire side) that is concave during bending.

3.2 *Bending resistance index, F_B^w* – Bending resistance divided by the cube of the grammage.

3.3 *Test span length* – The distance between the piviot axis and the knife edge (here 50 mm or 10 mm).

4 Principle

A rectangular test piece is clamped at one end. The surface of the test piece is in contact with a blunt knife-edge mounted on, and held by, a force sensor. The clamp is turned through 15° about an axis at the edges of the clamp, and the force, due to bending of the test piece thus applied to the knife-edge, is measured by the force sensor.

5 Apparatus

5.1 A *bending resistance tester*, *Figure*, consisting of:

5.1.1 *Clamp*, at least 38 mm wide and at least 20 mm long with two flat and parallel jaws clamping the test piece uniformly. Normally, a clamping pressure of (200 ± 50) kPa is suitable.

> *Note* – Too low a clamping pressure will give too low a bending resistance due to slippage between the surfaces of the jaws and the test piece.
>
> Too high a clamping pressure may, if thickness reduction occurs in the testing of low density papers, also give too low a bending resistance.
>
> In case of uncertainty, make tests with varying clamping pressures. In general, the correct clamping pressure may be considered to be that which gives the highest bending resistance.

In its starting position, the clamp holds the test piece parallel to the vertical plane. The clamp can be pivoted about an axis through the front edge of the clamping nip, and turned at a constant speed of (5,0 ± 0,5)°/s through a bending angle of (15,0 ± 0,1)° or of (7,5 ± 0,1)°.

5.1.2 *Knife*, mounted perpendicular to the initial movement of the test piece. The edge of the knife is parallel to the pivot axis of the clamp. The length of the edge is (16 ± 2) mm and the edge is centrally placed relative to the width of the test piece. The edge of the knife is rounded and the distance from the edge to the pivot axis of the clamp (the test span length) is adjustable to (50,0 ± 0,1) mm or to (10,0 ± 0,1) mm. The knife is also adjustable in the direction perpendicular to the plane of the test piece. It is important that the force sensor has a low sensitivity to lateral forces. The movement of the sensor in its response direction shall be less than 0,05 mm.

5.1.3 *Instrument,* indicating the force exerted on the knife-edge by the test piece when it is bent through an angle of 15° or 7,5°. The accuracy of the force at static calibration shall be 2 % or better of the reading over the entire range of measurement.

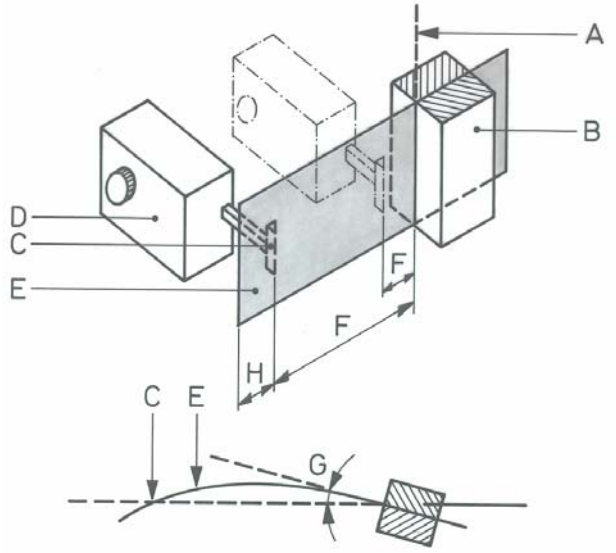

Figure. Principle of the bending resistance tester.

A *Pivoting axis*
B *Clamping device*
C *Blunt knife-edge*
D *Force sensor with adjustable knife*
E *Test piece*
F *Test span (50 mm or 10 mm)*
G *Bending angle (15° or 7,5°)*
H *Free length of the test piece*

5.1.4 *Arrangement for calibration of the force sensor* by weight or other means.

5.1.5 *Arrangement for calibration of the bending angle*.

5.2 *Device for cutting test pieces* in accordance with required test piece tolerances.

6 Calibration

Calibrate the force sensor and the bending angle by using instruments (5.1.4 and 5.1.5) with known accuracy.

7 Preparation of rectangular test pieces

7.1 *Sampling*. The sampling procedure is not covered by this Method. Make sure that the test pieces taken are representative of the sample received.

7.2 *Conditioning*. Condition specimens of paper and board as specified in ISO 187. Keep them in the conditioning atmosphere throughout the test.

7.3 *Preparation of test pieces*. Determine the average grammage of the specimens as described in ISO 536.

From specimens of undamaged paper and board free from watermarks, folds and wrinkles, cut with the longer side parallel to the machine (or cross) direction, test pieces (38,0 ± 0,1) mm wide and long enough to put through the clamp and have a free length (7 ± 3) mm longer than the test span length. Cut a sufficient number of test pieces to enable at least 10 tests to be made in both machine and cross direction.

Note – Several test pieces may be cut simultaneously provided that the test pieces formed fulfil the requirements specified above and if a preliminary test confirms that the test pieces formed give the same results as test pieces cut one at a time.

8 Procedure

Choose the test span length (50,0 ± 0,1) mm.

Place the test piece with one end entirely in the clamp and the other end extending (7 ± 3) mm beyond the knife-edge. Clamp the test piece and adjust the knife of the pivoting clamp carefully until the edge just makes contact with the test piece along a line.

Start pivoting the clamp, and note the reading in millinewtons at a bending angle of 15°.

To fulfil the required measurement accuracy (5.1.3) it may, for samples with low bending resistance, be necessary to decrease the test span length to 10 mm. The part of the test piece extending beyond the edge of the knife should be kept at (7 ± 3) mm. State the test span length in the report.

If the maximum force reading is obtained before the test piece has been turned through 15°, a crack in the test piece is indicated and the reading shall be rejected. If more than 10 % of the test pieces crack, repeat the test with a bending angle of 7,5° and state this in the report.

Use each test piece only once. Test at least 10 test pieces from each sample in the cross direction and at least 10 test pieces in the machine direction. For each direction make half of the tests towards the wire side and half of the tests towards the top side, see 3 Definitions and 9.2 Bending resistance.

Note – Highly twisted or curled test pieces will give unreliable results. It is not possible to straighten curved or twisted samples without modifying the properties of the material.

9 Calculation

9.1 *Symbols used in the calculations*

F_B is the bending resistance, in millinewtons;
$F_{B,MD}$ is the bending resistance in MD (machine direction), in millinewtons;
$F_{B,CD}$ is the bending resistance in CD (cross direction), in millinewtons.

The following suffixes are recommended to identify the bending angle and the test span length:

(50/15) is the bending of a test piece, with 50 mm test span length, through an angle of 15°;
$F_{B,MD(50/15)}$ is the bending resistance in MD when bending the test piece, with 50 mm test span length, through an angle of 15°.

9.2 *Bending resistance*

Calculate the mean bending resistance, F_B, and the standard deviation separately for the two sides. If the difference between the means exceeds 10 %, report them separately, otherwise report the grand mean.

Report the bending resistance in the machine direction, $F_{B,MD}$, and in the cross direction, $F_{B,CD}$, in millinewtons to three significant figures.

Note – Values cannot be linearly converted from one test span length to another or from one bending angle to another.

9.3 *Bending resistance index*

If required, calculate the bending resistance index as follows:

$$F_B^w = 10^6 F_B / w^3 \qquad [1]$$

where
F_B^w is the bending resistance index, in newton-metres^6 per cubic kilogram;
F_B is the bending resistance, in millinewtons;
w is the grammage of the sample, in grams per square metre.

Report the bending resistance index to three significant figures.

10 Report

The test report shall include reference to this SCAN-test Method and the following particulars:

(a) date and place of testing;
(b) identification mark of the sample tested;
(c) the bending angle (15° or 7,5°);
(d) the test span length (50 mm or 10 mm);
(e) the results as specified in section 9;
(f) the standard deviation or the coefficient of variation;
(g) any departure from the procedure described in this SCAN-test Method and any other circumstances that may have affected the results.

11 Precision

In an interlaboratory study, eight laboratories measured the bending resistance at a bending angle of 15° and in addition to that six of these eight laboratories measured at a bending angle of 7,5°. Five different paper grades were used. The results were as follows:

Table 1. Coefficients of variation in the determination of bending resistance. The test span length was 50 mm.

Sample grammage g/m²	Testing direction	Bending angle 15°			Bending angle 7,5°[1)]		
			Coefficients of variation			Coefficients of variation	
		Bending resistance mN	Between labs %	Within lab %	Bending resistance mN	Between labs %	Within lab %
80	MD	135	11	7	65	21	8
	CD	56	10	12	29	21	12
180	MD	69	6	4	36	10	4
	CD	36	9	4	19	12	7
200	MD	139	5	3	71	7	3
	CD	74	6	3	39	8	4
260	MD	372	4	3	193	7	3
	CD	126	6	6	68	9	7
380	MD	713	5	2	382	6	3
	CD	374	5	2	199	8	3

[1)] The recommended bending angle is 15°.

SCAN-test Methods are issued and recommended by KCL, PFI and STFI-Packforsk for the pulp, paper and board industries in Finland, Norway and Sweden.
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