SCAN-P 80:98
Accepted 1998

SCANDINAVIAN PULP, PAPER AND BOARD
TESTING COMMITTEE

Papers and boards

Z-directional tensile strength

0 Introduction

This SCAN-test Method has been developed in order to specify the conditions for determining the z-direction (thickness direction) tensile strength of paper and board.

The terminology for the strength properties in the z-direction is not well defined. Terms such as z-direction tensile strength, Scott Bond, internal bond strength, internal fibre bond strength, ply adhesion and ply bond strength are used, depending on the measurement procedure, on the type of sample tested and on the purpose of the measurement.

In this method, z-directional tensile strength is defined as the maximum tensile stress in the z-direction which a test piece can withstand before it breaks when it is loaded perpendicular to the plane in a tensile apparatus.

1 Scope

This Method is applicable to papers and boards having a grammage exceeding 60 g/m^2 and a maximum z-direction tensile strength less than approx. 500 kPa according to this method.

Note – Paper with a grammage lower than 60 g/m^2 may still be tested provided that it can be shown that the tape does not reinforce the paper.

2 References

ISO 187 Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples (EN 20187)

SCAN-G 2 Statistical treatment of test results

Note – SCAN-test has withdrawn a number of test methods and refers instead to the corresponding ISO and/or EN Standards.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

3.1 *Z-directional tensile strength* – The maximum tensile stress a paper or board can withstand, when it is loaded perpendicular to the plane of the material, under the conditions described in this Method.

4 Principle

A test piece, attached by double-sided adhesive tape between two flat metal surfaces of given area and pressed together under given stress and time, is strained to break during a given time of loading, using a tensile apparatus that records the maximum tensile force.

5 Apparatus

5.1 *Compression device* for bonding the tape to the test piece and to the tester platens with a compression force of (3 ± 0,5) MPa.

5.2 *Tensile apparatus* having a tensile force measuring device, with an accuracy of ± 2 % of the scale reading between 50 N and 1000 N and an adjustable force loading rate which can be set so that rupture occurs within (3 ± 2) s.

5.3 *Two flat circular tester platens* having an area of (1000 ± 10) mm^2 (a diameter of approx. 35,7 mm) and mounted to a self-adjusting test head which compensates for any lack of parallelism between the two faces of the test piece.

The tester platens must be stiff so that the platen surfaces do not bend during the compression procedure or the tensile testing, e.g. made of 15 mm thick stainless steel.

5.4 *Device for aligning the tester platens* so that they are concentric within 0,5 mm.

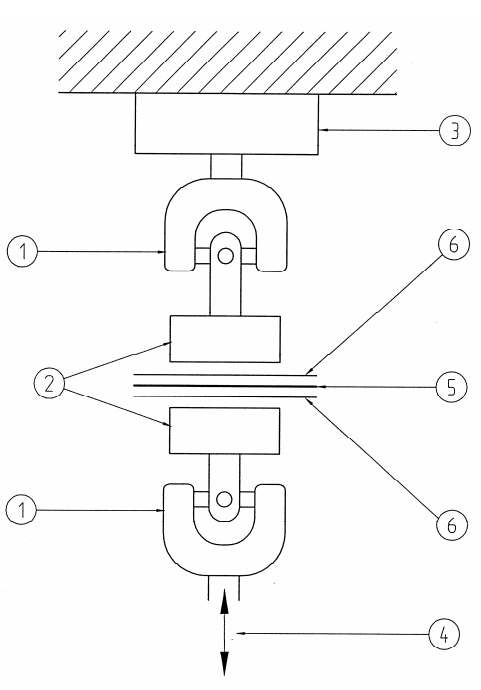

Figure 1. The principle for measuring z-directional tensile strength.

1. Self-adjusting heads
2. Tester platens
3. Force sensor
4. Compression and tensile device
5. Test piece
6. Double-sided self-adhesive tape

5.5 *Self-adhesive tape, double-sided,* having a minimum tensile stress of at least 500 kPa when the bonded strength of a single layer of double-sided self-adhesive tape is measured according to the procedure described in this Method.

Note 1 – Tape produced by 3M, type 410, or similar, is recommended.

Note 2 – The quality of the tape is affected by ageing. Follow the tape manufacturer's recommendation for storage.

5.6 *Punch or cutter for preparation of test pieces* with a size larger than the tester platens (5.3).

Circular test pieces with a diameter of approx. 50 mm or square test pieces approx. 50 mm × 50 mm are suitable.

5.7 *Solvent,* ethyl alcohol or similar.

6 Calibration

The apparatus shall be calibrated and checked according to instructions given by the manufacturer of the testing instrument.

Check the flatness of the surfaces of the tester platens by compressing a pressure-sensitive measuring film between the platens without any test piece. A uniform colour density indicates that the test surfaces of the tester platens are flat and uniformed loaded.

7 Sampling and preparation of test pieces

7.1 Sampling

The sampling procedure is not covered by this Method. Make sure that the specimens taken are representative of the sample received.

7.2 Conditioning

Condition the tape and the specimens of paper and board as specified in ISO 187 and keep them in the conditioning atmosphere throughout the test.

7.3 Preparation of test pieces

By using a punch or a cutter (5.6), cut the specified test pieces from specimens of undamaged paper and board, avoiding water marks, folds and wrinkles. The number of test pieces shall enable at least 5 tests to be made. Circular test pieces with a diameter of approx. 50 mm or square test pieces approx. 50 mm × 50 mm are suitable.

Note – The test piece area under test is determined by the area of the tester platens (5.3), i.e. a test area of 1000 mm^2.

8 Procedure

8.1 Mounting a test piece between the tester platens

Clean the tester platens with a solvent (5.7) prior to each day's testing. Dry the platens with a dry tissue or a soft cloth. Maintain the test surface of the platens in a clean state at all times.

Remove the protective liner from one side of a piece of the self-adhesive tape (5.5) and fix the tape to one side of the test piece so that it covers an area at least as large as the platens (5.3). Repeat this procedure on the other side of the test piece.

Remove the protective liner from the tape on both sides of the test piece.

Place the test piece between the aligned tester platens so that the test piece protrudes outside the tester platens at least 4 mm. Make sure that the tape completely covers the platen.

Compress the test piece between the tester platens with a force of $(3 \pm 0{,}5)$ MPa during (6 ± 2) s. Avoid bending or pulling the tester platens when the test piece is attached.

8.2 Measurements

Strain the test piece to break and record the maximum force, F.

Remove the test piece from the tester platens. Be careful not to touch the test surface of the platens.

> *Note 2* – If the tester platens must be touched to remove the tape or other material, clean the tester platens again with solvent (5.6) and dry them.

Study the rupture surface and make sure that rupture has occurred within the test piece. Any indication of tape-platen bond failure or tape-test piece bond failure invalids a test.

Carry out at least 5 approved determinations.

9 Calculation

Calculate the mean z-directional tensile strength, in kilopascals, from the expression:

$$\sigma_{ZD} = \frac{F}{A} \cdot 10^3 \qquad [1]$$

where

σ_{ZD} is the maximum tensile stress, in kilopascals;
F is the mean maximum tensile force, in newton;
A is the area of the tester platens, i.e. 1000 mm^2.

Report the z-directional tensile strength to three significant figures. Calculate also the coefficient of variation of the result.

10 Precision

In an interlaboratory test, five laboratories tested samples of paper and board from the same gross sample. The repeatability (coeff. of variation within lab) and the reproducibility (coeff. of variation between labs) were as follows:

Sample	Z-directional tensile strength, kPa	CV*, within lab, %	CV*, between labs, %
Copy paper, 80 g/m^2	449	4	2
Paperboard, 186 g/m^2	375	2	3
Paperboard, 220 g/m^2	328	2	7
Paperboard, 300 g/m^2	237	4	4

* CV is the coefficient of variation, i.e. the standard deviation divided by the mean value.

11 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 material tested;
(c) the z-directional tensile strength in kPa;
(d) the coefficient of variation of the results;
(e) any departure from the procedure described in this Method and any other circumstances that may have affected the result.

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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