INTERNATIONAL STANDARD

ISO 15754

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Paper and board — Determination of z-directional tensile strength

Papier et carton — Détermination de la force de traction dans la direction z

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15754 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

Introduction

This International Standard has been developed in order to specify the conditions for determining the z-directional tensile strength of paper and board, i.e. the tensile strength in the z-direction.

The terminology for the strength of paper in the thickness direction is not well defined. Terms such as z-directional 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.

Paper and board — Determination of z-directional tensile strength

1 Scope

This International Standard specifies a method for the determination of z-directional tensile strength, i.e. the tensile strength in the z-direction. It is applicable to paper and board, but not applicable to corrugated fibreboard.

For papers, the grammage range can not be stated explicitly, but results for papers having a grammage less than 60 g/m^2 shall be treated with caution since the tape may reinforce the paper.

This International Standard does not determine the absolute strength of paper as the measurement is affected by the tape, the pressing conditions and the speed used.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
z-direction
direction perpendicular to the plane of the material

3.2
z-directional tensile strength
maximum tensile stress a paper or board can withstand, when it is loaded in the z-direction under the conditions described in this International Standard

4 Principle

A test piece, attached to and between two flat metal plates using double-sided adhesive tape and given pressure for a specified time, is strained to break during a given time of loading, using a tensile-testing apparatus that records the maximum tensile force in the z-direction.

5 Apparatus

5.1 Compression device, for bonding the tape to the test piece and to the tester platens, with a compression force corresponding to (1,4 ± 0,1) MPa.

5.2 Tensile-testing apparatus, having a tensile force measuring device, reading to an accuracy of ± 2 % across the range of the load cell.

NOTE A force measuring device with a maximum capacity of 1 kN has been found to be suitable.

The dynamic performance of the testing instrument is a critical parameter in this test where a peak force shall be determined within a very short time. Care shall be taken on the sampling rate and the force signal filtering which includes the mechanical design of the instrument in use. It is the task of the manufacturer of the testing instrument to provide a testing instrument that can capture the peak force with sufficient accuracy.

The tensile-testing apparatus shall have a drive unit which allows test speed settings according to 6.3.

5.3 Two flat circular or **square tester platens**, having a test area of either (645 ± 10) mm^2 or (1 000 ± 10) mm^2.

Platen parallelism can be achieved either by a self-adjusting (swivel) mounting or by laterally guided, rigid compression platens. In the latter case, the parallelism tolerances shall be better than 0,000 5 mm/mm when measured in the longest horizontal direction of the platen test surfaces.

NOTE In some constructions, one platen can be larger than the other. In that case, the test-area is determined by the smallest area.

The tester platens shall be stiff so that the platen surfaces do not bend during the compression procedure or the tensile testing.

5.4 Device for aligning the tester platens, so that their vertical axes are aligned within 0,5 mm.

5.5 Double-sided adhesive tape, that is stronger than the tested sample and larger than the tester platens.

NOTE 1 It is not possible to state either the brand of the tape or the strength characteristics of the tape. Manufacturers constantly change the formulation and properties.

NOTE 2 The quality of the tape is affected by ageing. The tape manufacturer's recommendation for storage is followed.

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

5.7 Solvent, ethyl alcohol or similar.

6 Calibration

6.1 General

Calibrate or verify the apparatus parameters according to instructions given by the manufacturer of the testing instrument.

6.2 Checking

Check that the platens are parallel in accordance with the specifications given in 5.3, and that they are aligned according to the specification given in 5.4.

6.3 Test speed setting

This International Standard requires that a stress of 500 kPa shall be reached in (200 ± 20) milliseconds, i.e. a stress rate of 2,5 N/mm^2 per second. The corresponding elongation rate is dependent on the stiffness of the testing equipment. The required stress rate can be obtained by adjusting the elongation rate in such a way that this condition is fulfilled. Perform the calibration as follows.

For the platen size used, calculate the force, F, as the stress (500 kPa = 0,5 N/mm^2) times the area (645 mm^2 or 1 000 mm^2). Fasten the platens together with one layer of double-sided adhesive tape between the platens. Record the force versus the time. Perform a preliminary test by choosing an arbitrary elongation rate (around 60 mm/min) and record the time from zero force to the force, F (322,5 N or 500 N). If the time is not correct, adjust the elongation rate. Repeat this procedure until the time is (200 ± 20) milliseconds. Then accept this elongation rate, ER, and use this elongation rate for all future tests, irrespective of the paper to be tested or the tape used.

NOTE The elongation rate, ER, is usually supplied by the manufacturer of the instrument.

7 Sampling and preparation of test pieces

7.1 Sampling

If the test is being made to evaluate a lot of paper or board, carry out the sampling in accordance with ISO 186. If the test is made on another type of sample, report the source of the sample and if possible, the sampling procedure used.

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

From specimens of undamaged paper and board, cut the specified test pieces, avoiding watermarks, folds and wrinkles. The number of test pieces shall enable the accomplishment of at least five tests. The size of the test pieces must be larger than the size of the platens.

NOTE The test piece area under test is determined by the area of the tester platens (5.3).

8 Procedure

8.1 Mounting a test piece between the tester platens

Clean the tester platens (5.3) 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. Do not touch the cleaned platens with bare hands.

Remove the protective liner from one side of a piece of the double-sided 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 slightly protrudes outside of the tester platens. Make sure that the inner surfaces of both platens are completely covered with tape.

Compress the test piece between the tester platens with a force corresponding to a pressure of (1,4 ± 0,1) MPa for (6 ± 1) s. Avoid bending or pulling the tester platens while the test piece is attached.

8.2 Measurements

Strain the test piece to break, using the test speed setting selected according to 6.3 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.

If the tester platens are touched when removing the tape or other material, clean the tester platens again with solvent (5.7) and dry them. Never use sharp tools to remove the tape from the platens. Make sure that the platen surfaces are not damaged.

Visually study the paper surfaces after failure and make sure that the break has occurred within the test piece. If the fracture occurs between the tape and the platen or between the tape and test piece, discard the result from this particular test.

If 20 % or more of the test results are invalid because failure has not occurred in the sample, replace the tape with a stronger tape to comply with 5.5. Discard all previous results and repeat the testing.

NOTE If, after changing the tape and a stronger tape is not available, 20 % or more invalid results are still obtained, the sample may still be tested by using a higher pressing pressure and/or pressing for a longer time. The results obtained do not comply with the requirements of this International Standard.

Carry out at least five valid measurements.

9 Calculation

Calculate the mean z-directional tensile strength, σ_{ZD}, in kilopascals, using Equation (1):

$$\sigma_{ZD} = \frac{\bar{F}}{A} 10^3 \quad (1)$$

where

$\bar{F}$ is the mean maximum tensile force, in newtons;

A is the area of the tester platens, in square millimetres.

Report the z-directional tensile strength, σ_{ZD}, to three significant figures. Calculate, also, the coefficient of variation, CV, of the z-directional tensile strength.

10 Precision

10.1 Repeatability

In an interlaboratory comparison study, using the test speed setting specified in this International Standard, 12 laboratories tested three different paper grades; sack paper, kraft liner and paperboard. Five different instrument suppliers were represented. For each laboratory, the average of five measurements of each paper grade was reported.

The average coefficient of variation, CV, for the 11 participating laboratories was 5,3 %, 4,5 % and 3,7 %, respectively, for the three paper grades. Rejection of extremes according to Dixon and Massey[1] was performed.

10.2 Reproducibility

In an interlaboratory comparison study, using the test speed setting specified in this International Standard, 12 laboratories tested three different paper grades; sack paper, kraft liner and paperboard. Five different instrument suppliers were represented. For each laboratory the average of five measurements of each paper grade was reported.

The results are given in Table 1. Rejection of extremes according to Dixon and Massey[1] was performed.

Table 1 — Reproducibility data

Sample	Mean value, z-tensile strength kPa	Standard deviation, s kPa	Coefficient of variation %	Reproducibility limit, R [a] kPa
Sack paper	668	146	21,8	405
Kraft liner	444	65,1	14,6	180
Paperboard	285	39,1	13,7	108
NOTE The recommendations in ISO/TR 24498[2] have been applied.				
[a] $R = 1{,}96\sqrt{2} \cdot s_R$				

11 Test report

The test report shall include the following information:

a) reference to this International Standard, i.e. ISO 15754;

b) the date and place of testing;

c) the conditioning atmosphere used;

d) all the information necessary for complete identification of the sample;

e) the adhesive tape used (brand and type);

f) the z-directional tensile strength, in kilopascals;

g) the coefficient of variation of the z-directional tensile strength;

h) any deviation from this International Standard and any other circumstances that may have affected the result.