International Standard 1924/1

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Paper and board — Determination of tensile properties — Part 1: Constant rate of loading method

Papier et carton — Détermination des propriétés de traction — Partie 1: Méthode à vitesse constante d'application de charge

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1924/1 was developed by Technical Committee ISO/TC 6, *Paper, board and pulps.*

It was submitted directly to the ISO Council, in accordance with clause 6.11.2 of part 1 of the Directives for the technical work of ISO. This first edition of ISO 1924/1 cancels and replaces International Standard ISO 1924-1976, which itself replaced ISO Recommendation R 1924-1971, and incorporated the amendment which had been approved by the member bodies of the following countries:

Australia	India	Romania
Belgium	Iran	South Africa, Rep. of
Canada	Ireland	Sweden
Czechoslovakia	Italy	Switzerland
Finland	Mexico	Turkey
France	Netherlands	United Kingdom
Germany, F.R.	New Zealand	USA
Hungary	Norway	

The member body of the following country had expressed disapproval of the document on technical grounds:

Bulgaria

Printed in Switzerland

Paper and board — Determination of tensile properties — Part 1: Constant rate of loading method

0 Introduction

The method specified in this part of ISO 1924 for the determination of tensile strength is similar to the method specified in ISO 1924/2. The method uses a test instrument operating at a constant rate of application of tensile force (constant rate of loading) which causes failure of the test piece in a mean time of 20 ± 5 s. The method described in ISO 1924/2 uses an instrument operating at a constant rate of elongation.

1 Scope and field of application

This part of ISO 1924 specifies a method of measuring the tensile strength and stretch at break of paper and board using a test instrument operating at a constant rate of application of tensile force (constant rate of loading) which causes failure of the test piece in a mean time of 20 ± 5 s. It also specifies methods for calculating the breaking length and tensile index.

It applies, within the limitations of the instruments used, to all papers and boards with the exception of combined corrugated board, but may be applied to the components of such board.

This part of ISO 1924 is of general application and is not limited to any particular type of tensile testing apparatus.

2 References

ISO 186, *Paper and board — Sampling for testing.*

ISO 187, *Paper and board — Conditioning of samples.*

ISO 536, *Paper and board — Determination of grammage.*

ISO 1924/2, *Paper and board — Determination of tensile properties — Part 2: Constant rate of elongation method.*

ISO 5270, *Pulps — Laboratory sheets — Determination of physical properties.*

3 Definitions

For the purpose of this part of ISO 1924, the following definitions apply:

3.1 tensile strength: The maximum tensile force per unit width that paper and board will withstand before breaking under the conditions defined in the standard method of test.

3.2 breaking length: The calculated limiting length of a strip of paper or board of any uniform width, beyond which, if such a strip were suspended by one end, it would break under its own weight.

3.3 tensile index: Tensile strength (expressed in newtons per metre) divided by grammage.

3.4 stretch at break: The measured elongation at the moment of rupture of a test piece of paper or board when extended under conditions defined in the standard method of test. It is usually expressed as a percentage of the initial test length.

4 Principle

A test piece of given dimensions is stretched to rupture at a constant rate of loading using a tensile testing apparatus that measures tensile force and, if required, the elongation of the test piece. The maximum tensile force and, if required, the corresponding elongation are recorded.

From the results obtained and a knowledge of the grammage of the sample, the breaking length and tensile index may be calculated.

5 Apparatus

Any system may be used which is capable of acting on the test piece at the defined rate and of permitting the tensile force at the moment of failure to be read to an accuracy of ± 1 % and the elongation to an accuracy of ± 0,5 mm.

NOTE — For precise work on papers having a relatively low stretch (less than 2 %) the stretch attachment of the usual pendulum tester is not very accurate, because of deficiencies in the release mechanism. Instruments of the constant rate of elongation (CRE) type with electronic amplification and recording are recommended (see ISO 1924/2).

The rate of loading should be so adjustable that failure of the test piece can be obtained in a mean time of 20 ± 5 s (see note 1). When a substantially inextensible material is gripped between the clamps and a full scale reading is obtained in 20 s, the rate of loading at any time shall not differ by more than 5 % (see note 2) from the rate of loading 1 s later.

NOTES

1 This rate is not always possible on all types of paper without modification using existing commercial testing apparatus. (For rapidity in routine testing, 10 ± 5 s is often used but this will give results about 2 % higher than the specified method.)

2 In order to meet this requirement, pendulum type instruments should not be operated at pendulum angles greater than 50°.

The clamps shall grip the test piece firmly along its full width, without slipping or damage throughout the test.

The centre line of the clamps and of the test piece shall lie along the same axis, which shall also be parallel to the direction of the applied force. The clamping surfaces of the two clamps (flat clamps) or lines of contact (line contact clamps) shall be in the same plane and so aligned that they hold the test piece in that plane throughout the test.

The distances between the clamping lines shall be adjustable to the test length required to within ± 1,0 mm and shall remain parallel to within ± 1° for the duration of the test. In addition, the clamping lines shall remain perpendicular to the direction of the applied tensile force and to the long dimension of the test piece within ± 1° during the test.

A device is also required for cutting test pieces of the required dimensions (see clauses 8 and 9).

6 Sampling

Sampling shall be carried out in accordance with ISO 186.

7 Conditioning

Samples shall be conditioned in accordance with ISO 187.

8 Preparation of test pieces

Carry out the preparation of the test pieces in the standard atmospheric conditions used for conditioning the sample.

If the breaking length or tensile index is required, determine the grammage of the sample in accordance with ISO 536.

Prepare test pieces from specimens taken at random from those selected in accordance with clause 6. No creases, obvious flaws or watermarks shall be included in the test area and test pieces shall not include any part of the sample within 15 mm of the edge of any sheet or roll. If it is necessary to include watermarks, this fact shall be reported.

NOTE — Laboratory handsheets are excluded from the restriction that the test pieces shall not include any part within 15 mm of the edge.

Cut test pieces one at a time. Cut sufficient test pieces to ensure 10 valid results are obtained in each principal direction of the paper or board, the machine and cross directions (see 9.2).

The long edges of the test pieces shall be straight, parallel to within ± 0,1 mm, cleanly cut and undamaged.

NOTE — Some paper, for example soft tissue, is difficult to cut cleanly. In such cases, a pad of two or three sheets of tissue interleaved width a harder paper, for example bond, may be prepared and the test pieces cut from this pad.

The dimensions of the test pieces shall be as follows:

a) the width shall be 15, 25 or 50 mm, with a tolerance of −0,1 mm and + 0,2 mm;

NOTE — All widths have equal status and the selection of width is governed by the width of the clamps of the available apparatus and/or the type of paper or board under test.

b) the length shall be such that the test piece can be clamped without handling the section of the test piece between the clamps; a minimum length of 250 mm is usually sufficient. When testing laboratory hand sheets, special instructions apply; see ISO 5270.

NOTE — Some product dimensions, for example toilet tissue, are less than the required test span of 180 mm. In these cases, use the longest test length that can be achieved and record the length used in the test report.

9 Procedure

9.1 Calibration of apparatus

Set up the apparatus as recommended by the manufacturer.

A suitable method of calibration is to apply weights to the clamp actuating the load indicating mechanism with the instrument otherwise in its normal working condition. Note the scale reading when the system comes into equilibrium in the same time as that used in actual testing. Check the correct operation of the indicating mechanism, which should be free from excessive backlash, lag, or friction. If errors of more than 1 % are found, use a correction curve.

Calibrate the extension measuring mechanism with inside vernier calipers over the entire load range. Construct a correction curve relating the movement of the clamps and the corresponding movement of the extension measuring apparatus.

9.2 Determination

Carry out the tests in the standard atmospheric conditions used for conditioning the sample.

Unless otherwise specified, carry out the operations involved in the measurement of the tensile strength of each test piece in the manner recommended by the manufacturer of the apparatus in use.

Verify the zero position of the measuring devices.

Adjust the clamps to the required test length and place the test piece in the clamps ensuring that the test area between the clamps is not touched by the fingers. Align and tightly clamp the test piece so that any observable slack is eliminated but the test piece is not placed under any significant strain. Ensure that the test piece is clamped in such a manner that its edges are parallel to the direction of application of the tensile force.

NOTE — It may be convenient to attach a small weight, for example of mass 10 g for light-weight paper, to the lower end of the test piece whilst placing it in the clamp in order to eliminate the slack.

By an initial trial experiment, select a rate of application of tensile force which causes failure in a mean time of 20 ± 5 s.

Commence the test and continue it until the test piece ruptures. Record the maximum tensile force exerted and, if required, the stretch at break.

Test at least 10 test pieces, cut in each principal direction of the paper or board, in order to obtain 10 valid results in each direction.

Record all readings, except for those test pieces which break within 10 mm of the clamps. However, if more than 20 % of the test pieces cut from a particular sample break within 10 mm of the clamps, reject all the readings obtained for that sample, inspect the testing apparatus for conformity with the requirements of clause 5 and 9.1 and take the appropriate remedial action.

10 Expression of results

10.1 General

Calculate and express separately the results obtained in each principal direction of the paper or board. For machine-made paper or board, these will correspond to the machine and cross directions. For laboratory hand sheets, no such distinction can be made.

10.2 Symbols

The symbols used in the formulae are as follows:

m = mean mass, in milligrams, of the strip between the clamps;

l_B = breaking length, in kilometres;

g = grammage, in grams per square metre;

S = tensile strength, in kilonewtons per metre;

l_i = initial test length between the clamps, in millimetres;

w = width of the test piece, in millimetres;

$\overline{F}$ = mean tensile force, in newtons;

Y = tensile index, in newtons metre per gram.

10.3 Tensile strength

10.3.1 Calculate the tensile strength of the test pieces from the formula

$$S = \frac{\overline{F}}{w}$$

Express the tensile strength to three significant figures.

NOTE — For light-weight paper (for example tissue), it may be preferable to express the tensile strength in newtons per metre.

10.3.2 Calculate the standard deviation of the results.

10.4 Breaking length

If required, calculate the breaking length from the formula

$$l_B = \frac{1}{9{,}8} \times \frac{S}{g} \times 10^3$$

or

$$l_B = \frac{1}{9{,}8} \times \frac{\overline{F}}{w \times g} \times 10^3$$

Alternatively, l_B may be calculated from the formula

$$l_B = \frac{\overline{F} \times l_i}{9{,}8 \times m}$$

NOTE — For instruments calibrated in kilograms-force, the formula becomes

$$l_B = \frac{\overline{F} \times l_i}{m}$$

10.5 Tensile index

If required, calculate the tensile index from the formula

$$Y = \frac{S}{g} \times 10^3$$

Express the tensile index to three significant figures.

Alternatively, Y may be calculated from the formula

$$Y = \frac{\overline{F}}{w \times g} \times 10^3$$

10.6 Stretch at break

10.6.1 If required, calculate the mean stretch at break of the test pieces in millimetres, then calculate the stretch at break as a percentage of the initial test length and express the results to the first decimal place.

10.6.2 Calculate the standard deviation of the results.

11 Precision

For test results each of which consists of the average of ten determinations, the following precision data apply.

11.1 Repeatability

The 95 % probability limit for the difference between two test results within a single laboratory is 2,5 to 8,0 % for different papers with a mean repeatability of 4,2 %.

11.2 Reproducibility

The 95 % probability limit for the difference between two test results from different laboratories is 7 to 33 % for different papers with a mean reproducibility of 14 %.

12 Test report

The test report shall include the following particulars:

a) reference to this International Standard;

b) precise identification of the samples;

c) date and place of testing;

d) the conditioning atmosphere used;

e) the principal directions, if any, of the paper and board in which the determination was carried out;

f) the width of test piece used for the test;

g) the test length used for the test;

h) the mean time to break to the nearest second;

j) the number of test pieces used in the test;

k) the number of readings taken;

m) the mean tensile strength to three significant figures;

n) if required, the breaking length to three significant figures;

p) if required, the tensile index to three significant figures;

q) if required, the mean stretch at break, expressed as a percentage of the initial test length, to the first decimal place;

r) the standard deviation of the results for tensile strength and, if required, stretch at break;

s) the grammage of the sample, if determined;

t) any departure from this International Standard and any circumstances that may have affected the results.