INTERNATIONAL STANDARD

ISO 1924-1

Second edition
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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 la charge

Reference number
ISO 1924-1:1992(E)

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.

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.

International Standard ISO 1924-1 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Sub-Committee SC 2, *Test methods and quality specifications for paper and board.*

This second edition cancels and replaces the first edition (ISO 1924-1:1983), of which it constitutes a technical revision.

ISO 1924 consists of the following parts, under the general title *Paper and board — Determination of tensile properties*:

— *Part 1: Constant rate of loading method*

— *Part 2: Constant rate of elongation method*

Annex A forms an integral part of this part of ISO 1924.

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Introduction

The method specified in this part of ISO 1924 for the determination of tensile strength is related 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 s $\pm$ 5 s. The method described in ISO 1924-2 uses an instrument operating at a constant rate of elongation.

The class of instruments covered by this part of ISO 1924 is being superseded by that covered by ISO 1924-2. Because of this, but recognizing that there is still a considerable number of constant rate of loading instruments in use, it is proposed that ISO 1924-1 will be withdrawn 10 years after publication.

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Paper and board — Determination of tensile properties —

Part 1:
Constant rate of loading method

1 Scope

This part of ISO 1924 specifies a method of measuring the tensile strength of paper and board using an 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 s ± 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 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 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 1924. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 1924 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 186:1985, *Paper and board — Sampling to determine average quality.*

ISO 187:1990, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring tne atmosphere and conditioning of samples.*

ISO 536:1976, *Paper and board — Determination of grammage.*

ISO 1924-2:1985, *Paper and board — Determination of tensile properties — Part 2: Constant rate of elongation method.*

ISO 5270:1979, *Pulps — Laboratory sheets — Determination of physical properties.*

ISO 5725:1986, *Precision of test methods — Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

3 Definitions

For the purposes of this part of ISO 1924, the following definitions apply.

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

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.

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. The maximum tensile force is 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

5.1 Tensile testing apparatus, designed to extend a test piece of given dimensions at an appropriate constant rate of loading and to measure the tensile force.

The rate of loading should be so adjustable that failure of the test piece can be obtained in a mean time of 20 s ± 5s (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 using existing commercial testing apparatus without modification. (For rapidity in routine testing, 10 s ± 5 s is often used but this will give results about 2 % higher than those corresponding to the specified method.)

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

The tensile testing apparatus includes the elements described in 5.1.1 and 5.1.2.

5.1.1 Means of measuring the tensile force to an accuracy of ± 1 %.

NOTE 3 Although many instruments with a constant rate of loading are equipped to measure elongation, the measurement is not very accurate and therefore the determination of stretch by this method is not recommended. Where the measurement of stretch at break is required, instruments of the constant rate of elongation type with electronic amplification and recording are recommended (see ISO 1924-2).

5.1.2 Clamps, two in number, for holding a test piece of the required width (see clause 8). Each clamp shall be designed to grip the test piece firmly, but without damage or slippage, along a straight line across the full width of the test piece.

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° while under load. 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° while under load.

5.2 Device for cutting test pieces to the dimensions required (see clause 8).

6 Sampling

Samples shall be selected in accordance with ISO 186.

7 Conditioning

Samples shall be conditioned in accordance with ISO 187 and test pieces shall be prepared and testing carried out in the same atmospheric conditions used to condition the samples.

8 Preparation of test pieces

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

Prepare the 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 shall be noted in the test report.

NOTE 4 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 in each required principal direction of the paper or board, i.e. the machine and cross directions (see 9.2).

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

NOTE 5 Some paper, for example soft tissue, is difficult to cut cleanly. In such cases, a pad of two or three sheets of such a paper interleaved with a harder paper, for example 70 g/m^2 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 mm, 25 mm or 50 mm, with a tolerance of ± 0,1 mm;

NOTE 6 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. However, width has a significant effect on the test results and comparison of tensile strength de-

terminations made with different widths is not recommended.

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 7 For some products, for example toilet tissue, dimensions 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 and adjustment of apparatus

Set up the apparatus as recommended by the manufacturer. Position the clamps so that the test length (the distance between the closest points at which the test piece is firmly gripped) is 180 mm ± 2 mm. Verify that the test length is correct by measuring the distance between the two impressions produced by the clamps when clamping strips of thin aluminium foil.

NOTE 8 In some circumstances a different test length may be used. For example, when testing board a test span of 200 mm ± 2 mm can be required.

9.2 Determination

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 device.

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 9 It may be convenient to attach a small weight, for example a mass of 10 g for lightweight 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 the test piece to fail in a mean time of 20 s ± 5 s.

Commence the test and continue it until the test piece ruptures. Record the maximum tensile force exerted and the time taken to rupture to the nearest second.

Test at least 10 test pieces, cut in each required principal direction of the paper or board, in order to obtain 10 valid results in each required 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 from the clamps, inspect the testing apparatus for conformity with the requirements of clauses 5 and 9.1 and take the appropriate remedial action if the apparatus is faulty. If no fault is found with the apparatus accept the results.

10 Calculation of results

10.1 General

Calculate and express separately the results obtained in each required 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 equations given in 10.3 to 10.5 are as follows:

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

l_B is the breaking length, in kilometres;

g is the grammage, in grams per square metre;

S is the tensile strength, in kilonewtons per metre;

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

w is the width of the test piece, in millimetres;

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

I is the tensile index, in newton metres per gram;

$\bar{f}$ is the mean tensile force, in kilograms-force.

10.3 Tensile strength

10.3.1 Calculate the tensile strength of the test pieces, expressed in kilonewtons per metre, from the equation

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

Express the tensile strength to three significant figures.

NOTE 10 For lightweight paper (for example tissue), it can be preferable to express the tensile strength in newtons per metre.

10.3.2 Calculate the standard deviation of the tensile force.

NOTE 11 When expressed as a percentage, the standard deviation of the tensile force is also the standard deviation of the tensile strength.

10.4 Breaking length

If required, calculate the breaking length, expressed in kilometres, from the equation

$$l_B = \frac{1}{9{,}81} \times \frac{S}{g} \times 10^3$$

or

$$l_B = \frac{1}{9{,}81} \times \frac{\bar{F}}{w \times g} \times 10^3$$

Alternatively, l_B may be calculated from the equation

$$l_B = \frac{\bar{F} \times l_i}{9{,}81 \times m}$$

NOTE 12 For instruments calibrated in kilograms-force, the equation becomes

$$l_B = \frac{\bar{f} \times l_i}{m}$$

10.5 Tensile index

If required, calculate the tensile index, expressed in newton metres per gram, from the equation

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

Express the tensile index to three significant figures.

Alternatively, I may be calculated from the equation

$$I = \frac{\bar{F}}{w \times g} \times 10^3$$

11 Precision

For test results each of which consists of the average of ten determinations, the following precision data apply (see ISO 5725).

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 information:

a) reference to this part of ISO 1924;

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 or board in which the determination was carried out;

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

g) the test span used for the test;

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

i) the number of valid test results used to calculate the mean;

j) the mean tensile strength, in kilonewtons per metre, to three significant figures;

k) if required, the breaking length, in kilometres, to three significant figures;

l) if required, the tensile index, in newton metres per gram, to three significant figures;

m) the standard deviation of the results for tensile strength;

n) the grammage of the sample, if determined;

o) any departure from this part of ISO 1924 and any circumstances that may have affected the results.

Annex A
(normative)

Calibration and adjustment of the apparatus

Calibrate the apparatus by applying 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. 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.

Verify that the clamps are aligned to meet the requirements of 5.1.2.