INTERNATIONAL STANDARD

ISO 5626

Second edition
1993-11-15

Paper — Determination of folding endurance

Papier — Détermination de la résistance au pliage

Reference number
ISO 5626:1993(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 5626 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 5626:1978), of which it constitutes a technical revision (see introduction).

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Introduction

A number of instruments for determining the folding endurance of paper are in existence, the most commonly used being the Köhler Molin, Lhomargy, the MIT and the Schopper instruments. This International Standard is therefore based upon these four types of instrument. It should be noted, however, that the instruments do not give identical results.

The first edition of this International Standard (ISO 5626:1978) specified that the result be reported as the logarithm (to the base 10) of the number of double folds before fracture. The reason for this was the widely held opinion that the relative folding endurances of different papers are best indicated when the test values are expressed logarithmically. This procedure is still valid. However, experience during the life of the 1978 edition has shown that the interpretation of logarithmic results has caused confusion and consequently results are frequently quoted as the number of double folds. In view of this, this International Standard allows the results to be reported as either folding endurance [the logarithm (to the base 10) of the number of double folds] or the fold number (the antilogarithm of the folding endurance).

It should be noted that the fold number as defined in this International Standard is not the mean of the observed number of double folds and is therefore different to the understanding of fold number which existed prior to 1978 and which still persists in some countries.

This page intentionally left blank

Paper — Determination of folding endurance

1 Scope

This International Standard specifies the methods for the determination of folding endurance of paper using Köhler Molin, Lhomargy, MIT and Schopper testers. It sets out the conditions to be observed when using these instruments, and gives the precautions to be taken in using each instrument.

Interpretation of the results is complicated by the fact that the different types of instrument included in this International Standard will give different numerical results for the same test material and they can produce dissimilar rankings for different test materials.

Annexes A, B and C give information on the instruments and their maintenance and calibration.

NOTE 1 The results obtained with the instruments described are very sensitive to atmospheric conditions under which the test is carried out, particularly humidity.

When operated with the standard loads, the Köhler-Molin, Lhomargy and Schopper methods are applicable to paper up to 0,25 mm thick and having a tensile strength greater than 1,33 kN/m.

The MIT tester has interchangeable folding heads allowing a range of thicknesses up to 1,25 mm to be accommodated.

This International Standard does not state any preferences for any particular method.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 the atmosphere and conditioning of samples.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 double fold: One complete oscillation of the test piece, during which it is folded first backwards and then forwards about the same line.

3.2 folding endurance: Logarithm (to the base 10) of the number of double folds required to cause rupture of the test piece when tested under applied standard stress conditions.

3.3 fold number: Antilogarithm of the mean folding endurance.

4 Principle of the methods

Folding backwards and forwards in a standardized manner of a narrow strip of paper subjected to a longitudinal stress, until it breaks.

5 Apparatus

5.1 Fold tester (see annex A).

Details for maintenance and calibration of instruments are given in annex B.

5.2 Means of measuring the temperature in the vicinity of the folding head.

NOTE 2 Heating of the paper in the test area, which results either from the work done on the paper or from heat transferred from the instrument motor via the jaws, can lead to local embrittlement of the paper test strip and thus to low

folding endurance results. These effects can be minimized by insulation or isolation of the drive motor from the remainder of the apparatus and by adequate ventilation of the area surrounding the folding head (see annex C).

5.3 If necessary, **means of ventilating** the space around the folding head, for example by mounting a fan next to the folding head to draw air across the test piece.

5.4 Device for cutting the test pieces.

6 Sampling

Take samples in accordance with ISO 186.

7 Conditioning

Condition the samples in accordance with ISO 187.

8 Preparation of test pieces

Prepare the test pieces in the same atmosphere used to condition the samples.

Cut at least 10 pieces in each required principal direction of the paper.

The test pieces shall be 15 mm ± 0,1 mm wide and of sufficient length for the instrument being used. Each edge shall be clean-cut and parallel to the opposite edge.

The test pieces shall be initially free from folds, wrinkles or blemishes not inherent in the paper. The area where the flexing takes place shall not contain any portion of a watermark.

Take care not to handle with bare hands any part of the test piece that will be exposed between the clamps.

9 Procedure

9.1 General

Carry out the tests in the same atmosphere used to condition the samples.

Throughout the test, monitor the air temperature in the vicinity of the folding head. The temperature shall not increase by more than 1 °C after 4 h of operation. If the temperature increases by more than 1 °C, stop the test and wait for the temperature to return to normal before restarting the test. Disregard the test in progress when the test was stopped.

If the number of double folds is less than 10 or greater than 10 000, decrease or increase the tension, if this is possible. The use of a nonstandard tension, and its value, shall be stated in the test report.

At least 10 readings for each required principal direction of the paper are required. The machine direction test is that in which the long axis of the test piece is in the machine direction of the paper and the stress is applied in the machine direction, the break being in the cross direction.

Reject any individual result where the test piece has slipped in the clamps or broken away from the fold line.

Determine the logarithm (to the base 10) of each of the individual readings. Calculate separately the mean of the values for machine and cross directions respectively.

If required (see clause 11), determine the antilogarithms of the means for machine and cross directions respectively.

Calculate the standard deviation of individual folding endurance values, i.e. the individual readings in logarithmic form, or, if required, the antilogarithm of this standard deviation.

For details concerning the operation of each type of instrument, see 9.2 to 9.5.

9.2 Schopper instrument

Level the instrument. Move the reciprocating blade so that its slot is in the neutral position and, in testers with a flyweheel, lock the flywheel into position by the spring stud that engages in the recess in the flywheel. Release the clamps by raising the cylinder locks. Place the test piece in the clamps. Make sure that the test piece and clamps are aligned correctly. Tighten the screws of the clamps so that the test piece is held firmly and evenly without possibility of slippage. Apply the tension to the test piece by drawing back the ends of the clamp cylinders until the cylinder locks engage.

Release the flywheel from the stud lock. Engage or switch on the counter. Commence folding and continue until the test piece breaks, when the counter will automatically stop. Record the number of double folds required to break the test piece.

Return the counter reading to zero.

9.3 Lhomargy instrument

Level the instrument. Place the appropriate loading weights on the platform provided. Use a tension of 9,81 N, unless the number of double folds is very low, in which case loading weights equivalent to a tension of 4,91 N may be used.

Insert the paper, in the form of a loop, in the two clamps above the loading weights, so that it is fully engaged. Lightly close the two knurled knobs. Ensure that the blade is in the vertical plane.

Take the loading weights in one hand and, with the other, engage the paper in the two lower rollers and in the slot of the blade. This slot should be in a convenient position, i.e. between the upper pair and the lower pair of rollers. Centre the part of the test piece that passes through the slot of the blade well on the rollers. Release the loading weights without jolting.

Set the engaging lever, commence folding and continue until the test piece breaks, when the counter will automatically stop. Record the number of double folds required to break the test piece.

Return the counter reading to zero.

9.4 Köhler Molin instrument

Level the instrument. Set the folding clamp so that the gap between the two jaws is approximately vertical. Lock the lower clamp in the raised position. Hold the test piece with its ends between the jaws of the folding and the lower clamps. Centre the test piece (guidelines are provided in the folding clamp and lower clamp) and tighten the clamps so that the test piece cannot slip during the test. Apply the load 800 g (7,85 N) to the lower clamp and set the revolution counter to the zero position or record the reading.

Release the lower clamp, commence folding and continue until the test piece breaks, when the counter will automatically stop. Record the number of double folds required to break the test piece.

Return the folding clamp and the lower clamp to their starting positions.

9.5 MIT instrument

Level the instrument. Turn the oscillating folding head so that the slot is vertical. Place a weight on top of the plunger, equivalent to the tension desired on the specimen, normally 9,81 N, tap the plunger sideways to eliminate friction and check and set the load indicator. Lock the plunger in position and, without touching the part of the strip to be folded, clamp the test piece firmly and squarely in the jaws, with the surface of the test piece lying wholly within one plane, i.e. flat, and with the sides free from the oscillating jaw mounting plate.

Unscrew the plunger lock and remove the weight, thus applying the specified tension to the strip. When removing the weight, also observe the load indicator for possible movement. If movement occurs, readjust the tension to that shown with the weight on the plunger. Commence folding and continue until the test piece breaks, when the counter will automatically stop. Record the number of double folds required to break the test piece.

Return the counter reading to zero.

10 Precision of the method

10.1 Repeatability

Repeatability is about 8 % for folding endurance values of about 1,5 (fold number approximately 30) decreasing to about 2 % for folding endurance values of about 3,5 (fold number approximately 3 000).

The difference between two single test results found on identical test material by one operator using the same apparatus within a short time interval will exceed the repeatability on average not more than once in twenty instances of the normal and correct operation of the method.

10.2 Reproducibility

Reproducibility is about 10 % for folding endurance values of about 1,5 (fold number approximately 30) decreasing to about 4 % for folding endurance values of about 3,5 (fold number approximately 3 000).

The difference between two single and independent results found by two operators working in different laboratories on identical test material will exceed the reproducibility on average not more than once in twenty instances of the normal and correct operation of the method.

NOTE 3 The values stated above are based upon results obtained during an international round-robin investigation carried out during 1971 under the auspices of ISO/TC 6/SC 2/WG 5, *Folding endurance*. The round robin used four different papers and involved a total of about 70 different instruments. The values given above are supported by results obtained since 1971 in routine round-robin checks carried out using a much wider range of papers, in, for instance, the United Kingdom and the USA.

11 Test report

The test report shall include the following particulars:

a) reference to this International Standard;

b) date and place of testing;

c) precise identification of the sample;

d) type of instrument used;

e) conditioning atmosphere used;

f) for each principal direction tested, either the mean folding endurance (see 3.2) reported to two decimal places or, if required, the fold number (see 3.3) reported to the nearest double fold or two significant figures according to the magnitude of the result;

g) for each principal direction tested, the maximum and minimum of the folding endurance values or, if required, the maximum and minimum number of double folds;

h) for each principal direction tested, the standard deviation of the folding endurance or, if required, the antilogarithm of this standard deviation and the number of tests on which the data are based;

i) the tension applied to the test piece;

j) any other circumstances or influences that may have affected the results.

Annex A
(normative)

Descriptions of folding testers

All four types of instrument are normally motor-driven. Appropriate measures are, or should be, taken by the manufacturer or user to minimize the effects upon results of vibration and heat from the motor. Such measures included positioning the motor as far away as possible from the place at which the folding takes place, the use of belt drive rather than direct drive, the use of fibre-to-metal transmission gears, and the use of fans to remove heat.

A.1 Schopper instrument

The instrument can be regarded as comprising three separate parts.

A.1.1 Device for folding the paper, consisting of a pair of horizontally opposed clamps which hold the test piece, four rollers and a thin slotted reciprocating blade. The clamps, approximately 90 mm apart, are anchored by springs and hold the test piece under tension in a vertical plane. The clamps are freely suspended while in motion between the tension springs, except that they are supported below by rollers. The four creasing rollers with their axes vertical are symmetrically placed about a point midway between the clamps. The slotted folding blade reciprocates in a vertical plane at right angles to the test piece through the point midway between the clamps.

The spring tension varies during the folding cycle and is such that when the test piece is straight and unbent each spring exerts a pull of 7,60 N ± 0,10 N; when the folding blade is at the limit of its travel and the test piece is bent to the maximum extent, the pull exerted by each of the springs is 9,80 N ± 0,20 N.

The four creasing rollers, each of diameter 6 mm and length 18 mm, are preferably provided with jewel bearings. The distance between the folding blade and the two creasing rollers on each side of it should be 0,3 mm and the width between rollers of the space occupied by the unbent test piece should be approximately 0,5 mm.

The thickness of the folding blade is 0,5 mm ± 0,012 5 mm. The edges of the vertical slot are cylindrical (radius 0,25 mm); they extend somewhat above and below the normal position of the test piece. The width of the slot in the blade is 0,5 mm ± 0,012 5 mm.

A.1.2 Means of driving the slotted reciprocating blade back and forth in simple harmonic motion at (115 ± 10) double folds per minute with a 20 mm stroke.

A.1.3 Counter, for registering the number of double folds, that stops automatically when the test piece breaks.

A.2 Lhomargy instrument

The instrument can be regarded as comprising three separate parts.

A.2.1 Device for folding the paper, consisting of a clamp assembly which holds the test strip at both ends, four rollers of diameter 14 mm and length 22 mm, mounted on ball bearings, and a blade 0,5 mm thick, slotted in its centre with a slot 0,5 mm wide which has its edges rounded to a semicircular cross-section. The distance between the axes of the rollers should be 15,1 mm.

The axes should be horizontal with two of the axes lying in the same vertical plane and the axes of the other two rollers lying in a different vertical plane.

The clamp assembly is loaded by dead weight, the weight being supported via the test strip by the roller assembly and the reciprocating blade during the test until the test piece fails.

The four creasing rollers with their axes horizontal are symmetrically placed about a point vertically above the centre of the clampling mechanism. The test piece passes horizontally between the upper pair and the lower pair of rollers when the reciprocating blade is in the mid-position. The slotted folding blade reciprocates in a vertical plane at right angles to the test piece between the left-hand and right-hand pairs of rollers with the test piece passing through the slot.

An appropriate dead weight load is selected to give a tension of 9,81 N or 4,91 N.

A.2.2 Means of driving the slotted reciprocating blade back and forth in simple harmonic motion at (125 ± 5) double folds per minute, with a 20 mm stroke, by an electric motor.