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Paper — Determination of folding endurance

Papier — Détermination de la résistance au pliage

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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.

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.

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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.

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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 $\pm$ 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 $\pm$ 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 $\pm$ 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 $\pm$ 0,012 5 mm.

A.1.2 Means of driving the slotted reciprocating blade back and forth in simple harmonic motion at (115 $\pm$ 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 $\pm$ 5) double folds per minute, with a 20 mm stroke, by an electric motor.

A.2.3 Counter for registering the number of double folds, that stops automatically when the test piece breaks.

A.3 Köhler Molin instrument

The instrument can be regarded as comprising four separate parts.

A.3.1 Upper folding clamp, consisting of a fixed jaw and a movable jaw, which grips one end of the test piece. The surfaces in contact with the test piece during folding should be semicircular in cross-section, with a radius of 0,25 mm. The pivot joint of the jaw shall be 0,04 mm from the edge of the fixed jaw of the clamp on a line connecting the folding edges of the two clamps.

A.3.2 Lower (loading) clamp, consisting of a fixed jaw and movable jaw, which grips the test piece at its other end. When in the operating position, the upper edge of the lower clamp should be 62 mm ± 1 mm below the line of contact of the upper clamp. The load on the clamp shall be 7,85 N ± 0,02 N, produced by a total mass, including all parts, of 800 g.

A.3.3 Means of producing (200 ± 10) complete oscillations of the folding head per minute through an angle of 156° ± 2° on each side of the vertical line.

A.3.4 Counter for registering the number of double folds, that stops automatically when the test piece breaks.

A.4 MIT instrument

The instrument can be regarded as comprising four separate parts.

A.4.1 Spring-loaded clamp, constrained to move vertically without horizontal rotation above the axis of rotation of a folding head located about 60 mm below its tip. The gripping surfaces of this clamp are in the plane of this axis, and a pivot above the gripping surfaces permits the clamp as a whole to swing in this plane. The load is applied by a spring attached to the clamp assembly and is adjustable to provide any desired tension on the test piece from a range of at least 4,91 N to 14,72 N. The load deflection of the spring is at least 17 mm/9,81 N, which is achieved by using a mass of 1 kg.

A.4.2 Oscillating folding head, having a slot to accommodate the test piece and surfaces parallel to, and symmetrically placed with respect to, its axis of rotation; it is emphasized that symmetrical placing is of the utmost importance. Each end of the surfaces forming the slot has a radius of curvature of 0,38 mm ± 0,02 mm and a width of not less than 19 mm.

The opening of the slot is great enough to allow the test piece to fall freely within it but with a clearance of not more than 0,25 mm. Accordingly, folding heads with the following widths of slots can be required:

0 mm to 0,25 mm;

0,25 mm to 0,50 mm;

0,50 mm to 0,75 mm;

0,75 mm to 1,00 mm;

1,00 mm to 1,25 mm.

In the head below the slot is a clamp with its nearest edge 9,5 mm below the axis of rotation, in which the lower end of the test piece is gripped.

A.4.3 Means of producing (175 ± 10) complete oscillations of the folding head per minute through an angle of 135° ± 2° on each side of the vertical line.

A.4.4 Counter for registering the number of double folds, that stops automatically when the test piece breaks.

Annex B
(normative)

Maintenance and calibration of the instruments

The results of the folding test are very sensitive to tension, arc of fold and radius of fold, so regular calibration and checking are very important.

B.1 Schopper instrument

Keep all moving parts, with the exception of the clamp tension springs, lubricated; for this purpose, a light machine oil is recommended. Carry out the oiling carefully and examine broken test pieces to see that they have not been stained with oil. All rollers shall revolve freely and the whole mechanism be kept free from dust, in particular paper dust.

The clamps shall hold the test piece firmly over its entire width. To test the clamps, a test piece is inserted and the spring tension applied and released several times. With the tension finally released, the test piece shall remain smooth and straight; buckling or waviness indicates a faulty clamp allowing the test piece to slip. Each clamp can also be checked individually by inserting a short strip of the correct width, and then, whilst holding the clamp firmly in one hand, attempting to rotate the strip up or down in its own plane, a movement which shows whether the paper is gripped evenly over its width. Occasionally, it can be found that the paper is not gripped evenly because a fragment of paper from a previous test has been left in the clamps by pulling out a broken strip without unscrewing the clamps sufficiently.

Calibration of the springs of the fold tester shall be carried out periodically. It is first necessary to scribe the shank of the clamp with two marks corresponding to the deflection of the spring in the neutral position when the tension is minimum and at the point of maximum travel of the folding blade when the tension is greatest. A convenient method of checking the spring tensions is to remove the jaws, together with their housings and supports, and clamp them for calibration in a vertical position. Any convenient clamp that can be accurately levelled may be used. The total weight suspended from the spring shall include the clamp and its link. A load of 7,60 N is applied to the spring and the extension of the clamp guide noted. The first mark should be just visible and if any adjustment is necessary to secure this, it shall be made by turning the milled head at the end of the cylinder.

NOTE 4 The minimum tension is much more important than the maximum tension and should be set as close as possible to the designated value.

Increase the load until the second mark coincides with the end of the cylinder. If this load is between 9,6 N and 10,0 N, the springs are in calibration. If it is more or less than this, a new set of matched springs shall be installed. The correct distance apart for the two marks is 8 mm.

Alternative methods have been described to enable the springs to be calibrated in position, such as by the use of a balance bell-crank lever. In these circumstances, it is not necessary to allow for the mass of the clamps.

The creasing rollers shall be examined to ensure that they are accurately parallel to each other and at right angles to the direction of motion of the test piece; they shall revolve freely. The two edges of the folding slot shall be parallel to each other and to the creasing rollers. The two edges of the folding slot shall be perfectly smooth and free of any surface imperfections.

Check with a stopwatch that the instrument performs (115 ± 10) double folds per minute.

NOTE 5 The above procedure takes no account of the change in radius of curvature of the slot, which does affect the results. It is recommended that all new instruments be "run in" on test pieces of the materials which would normally be tested until the readings stabilize.

B.2 Lhomargy instrument

Keep all moving parts, with the exception of the clamp tension springs, lubricated; for this purpose, a light machine oil is recommended. Carry out the oiling carefully and examine broken test pieces to see that they have not been stained with oil. All rollers shall revolve freely and the whole mechanism shall be kept free from dust, in particular paper dust.

The clamps shall hold the test piece firmly over its entire width. To test the clamps, a test piece is inserted and the appropriate load applied and released several times. With the tension finally released, the test piece shall remain smooth and straight; buckling or waviness indicates a faulty clamp allowing the test piece to slip. Each clamp can also be checked individually by inserting a short strip of the correct width, and then, whilst holding the clamp firmly in one hand, attempting to rotate the strip up or down in its own plane, a movement which shows whether the paper

is gripped evenly over its width. Occasionally, it can be found that the paper is not gripped evenly because a fragment of paper from a previous test has been left in the clamps by pulling out a broken strip without unscrewing the clamps sufficiently.

Check the masses of the clamp assembly and the loading weights. The masses shall be within 0,25 % of their nominal values.

The creasing rollers shall be examined to ensure that they are accurately parallel to each other and at right angles to the direction of motion of the test piece; they shall revolve freely. The two edges of the folding slot shall be parallel to each other and to the creasing rollers. The two edges of the folding slot shall be perfectly smooth and free of any surface imperfections.

Check with a stopwatch that the instrument performs (125 ± 5) double folds per minute.

B.3 Köhler Molin instrument

Regularly inspect the fold tester for cleanness and for faults such as wear, misalignment, loose parts and damage, paying particular attention to the condition of the surfaces of the jaws on the folding head. Clean the instrument and rectify any faults found. Apply oil regularly at the various oil holes, using a good quality light machine oil.

Check with a stopwatch that the instrument performs (200 ± 10) double folds per minute.

Check the functioning of the counter.

Check the angle through which the upper clamp turns by fastening in the clamp a stiff rule of a material that will not damage the surface of the clamp and turn the flywheel by hand, marking the extreme position on a piece of board. If the angle between the extreme position and the vertical is not 156° ± 2° in both directions, adjust the attachment of the clamp.

Check that the clamping action is uniform throughout the width of the clamp jaws by fastening two 3 mm wide strips of thin paper, such as cigarette tissue, in the instrument, one at either end of the clamp. If either of these strips is not tightly secured, the clamp shall be adjusted.

Check the alignment of the clamps. Fasten a paper strip in the instrument and turn the flywheel by hand to cause the folding clamp to turn through 90° in both directions. If this causes the lower clamp to swing sideways, as seen with the naked eye, the clamp is defective and shall be adjusted or replaced.

Check that the total mass of the lower clamp, loading bar and the weights used for the loading is 800 g ± 2 g.

Check that the loading bar is hanging freely.

Check that the stop on the upper clamp is correctly positioned. Fasten a plumb line in the upper clamp; the line shall bear against the stop, and the point of the plumb shall be immediately above the upper edge of the lower clamp. If not, adjust the stop of the top clamp until the point of the plumb is just above the inner stop of the lower clamp.

B.4 MIT instrument

Keep the moving parts correctly lubricated; for this purpose, a light machine oil is recommended. Carry out the oiling carefully and examine broken test pieces to verify that they have not been stained with oil.

Ensure that the folding edges are free from rust, dirt and oil, and that the counter operates properly.

Measure the plunger friction by determining the additional load required to cause a perceptible movement of the plunger when displaced under a load of 9,81 N. This friction shall not be more than 0,245 N.

Measure the change in tension due to eccentricity of the rotation of the folding edges, as follows.

Place a test piece, cut in the machine direction, in the tester as for making a folding test. Operate the tester for a number of folds up to 100, short of causing a near-break of the test piece, so as to flex the paper and minimize the effect of its stiffness. Rotate the folding head slowly through an entire folding cycle and measure the maximum change in displacement of the plunger with an accuracy of 0,1 mm; it is important that this displacement be "centred" with respect to the vertical position of the slot in the folding head. The displacement shall be no greater than that produced by an added mass of 35 g (equivalent to a load of approximately 0,34 N).

Measure the curvature of the folding edges by making casts, magnifying them in profile and comparing them with true circles. The two folding edges shall be at the same elevation when the slot head is vertical.

NOTE 6 When removing a short broken test piece, care should be taken not to use a needle or sharp edge that might score the folding edges.

To facilitate the removal of short test pieces, such as can be encountered when testing handsheets for pulp testing, a horizontal slot, about 3 mm wide, may be milled above the clamping bar in the folding head to about its centreline, to permit the use of a needle or knife point to remove the remnant without touching the folding edges of the head. This slot shall have no effect on the test.

Annex C
(informative)

Temperature rise limitations

Many instruments currently in use fail to meet the temperature rise limitations set in this International Standard. Useful information on the causes of the temperature rise and on corrective action are given in the following references.

[1] KAHLSON, T. and MARTENSSON, B. *Paperi ja Puu,* **46** (10) 581 (1964).

[2] KAHLSON, T. and LINDHOLM, S. *Paperi ja Puu,* **48** (10) 583 (1966).

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