

ISO

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION R 438

METHOD FOR THE DETERMINATION
OF THE BULKING THICKNESS AND BULK OF PAPER

1st EDITION

June 1965

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AMENDMENT 1 - JANUARY 1967
TO ISO RECOMMENDATION R 438-1965

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Page 6

Amend the second line of the table to read as follows:

Area of pressure foot	200 mm ² (nominal value)	0,31 in ² (nominal value)
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This Amendment is the logical result of the acceptance of ISO Recommendation R 534-1966,
Determination of the Thickness of Single Sheets of Paper.

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ISO/R 438:1965

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BRIEF HISTORY

The ISO Recommendation R 438, *Method for the Determination of the Bulking Thickness and Bulk of Paper*, was drawn up by Technical Committee ISO/TC 6, *Paper*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question by the Technical Committee began in 1958 and led, in 1961, to the adoption of a Draft ISO Recommendation.

In October 1961, this Draft ISO Recommendation (No. 475) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies:

Belgium	Greece	Romania
Brazil	Israel	Sweden
Bulgaria	Italy	Turkey
Czechoslovakia	Japan	U.A.R.
Denmark	Netherlands	United Kingdom
Finland	Norway	U.S.S.R.
France	Poland	Yugoslavia
Germany	Portugal	

Four Member Bodies opposed the approval of the Draft:

Australia Canada India U.S.A.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in June 1965, to accept it as an ISO RECOMMENDATION.

METHOD FOR THE DETERMINATION OF THE BULKING THICKNESS AND BULK OF PAPER

1. OBJECT AND SCOPE

This ISO Recommendation describes a method of measuring the bulking thickness of papers up to a substance of 250 g per square metre.

Knowledge of the bulking thickness and of the mass of the paper permits the calculation of the bulk.

2. DEFINITIONS

- 2.1** *Bulking thickness.* Thickness of a single sheet calculated from the measurement of the thickness of several superposed sheets (called a pack), when a static load is applied.
- 2.2** *Bulk.* Volume in cubic centimetres occupied by one gramme of paper in the form of a pack of superposed sheets.

3. PRINCIPLE

The method is based on the use of a precision dial micrometer to measure the thickness of a pack of sheets when a static load is applied.

Results for thickness are given in terms of the bulking thickness per sheet.

4. EQUIPMENT

4.1 Precision dial micrometer

This instrument is provided with two parallel plane faces between which the paper is placed for measurement. One of the faces should be capable of movement in a direction perpendicular to the other, which is fixed. The movable face (or pressure foot) should be circular. The fixed face (or anvil) should also be circular and of such size that the whole area of the pressure foot is in contact with the anvil in the zero position.

To ensure that the pressure between the faces is uniform within the limits given, the use of a dead weight rather than a spring is preferred.

The instrument should be checked in accordance with the procedure detailed in the Appendix and should conform to the following:

	Metric system	Inch system
Diameter of pressure foot	16 ± 0.5 mm	0.65 ± 0.02 in
Area of pressure foot	200 ± 10 mm ²	0.31 ± 0.015 in ²
Pressure exerted by the foot	1.00 ± 0.10 kgf/cm ²	14.2 ± 1.5 lbf/in ²
Repeatability of measurement (standard deviation)	≤ 0.0025 mm or 0.5 per cent*	≤ 0.0001 in or 0.5 per cent*
Indication error	± 0.0025 mm or ± 0.5 per cent*	± 0.0001 in or 0.5 per cent *
Error of parallelism of foot and anvil	≤ 0.0050 mm or 1 per cent*	≤ 0.0002 in or 1 per cent *

4.2 Auxiliary apparatus

A set of feeler gauges of thickness known to within 0.001 mm or 0.000 04 in.

4.3 Calibration of the instrument

The instrument should be calibrated at reasonable intervals. The Appendix gives details as to the procedure to be followed. For instruments in frequent use, it is suggested that the calibration be checked daily for repeatability and accuracy, and monthly for parallelism and foot pressure.

5. PREPARATION OF TEST PIECES

The test pieces (a minimum of four) are composed of the same number of sheets (a minimum of five). Each sheet is cut to a size of 20 cm × 25 cm** from a specimen taken at random from those that had been selected according to ISO Recommendation R 186, *Method of sampling paper for testing*, and then conditioned according to ISO Recommendation R 187, *Method for the conditioning of paper and board test samples*.

The sheets forming the test piece are superposed as a pack. The sheets should all face the same way, i.e. the wire side of one sheet should be against the top side of the other. Each sheet should be independent of the remainder; one sheet folded and inserted into the test piece to form two or more sheets is not satisfactory.

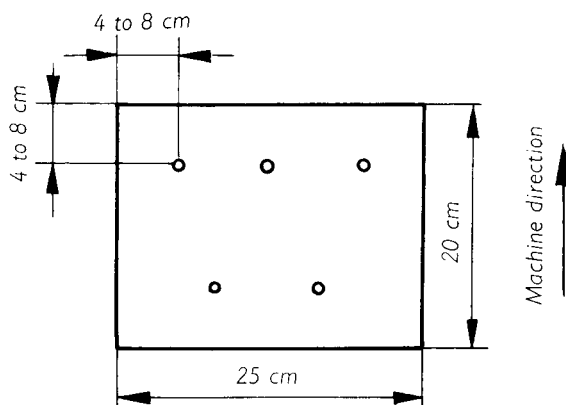
6. TEST PROCEDURE

The tests are made in the ISO standard reference atmosphere (see ISO Recommendation R 187, section 4).

Make five measurements on each test piece defined above. These measurements are made between 4 and 8 cm from the sides of the test piece and distributed along the two sides parallel to the cross direction of the paper, three on one side and two on the other, as indicated in the figure below.

* Whichever is the greater.

** The length of 25 cm being, where practicable, in the cross direction.



Place the test piece between the two faces of the instrument. Lower the pressure foot gently, slowly* and very carefully onto the test piece so that all punching effect is avoided; also, no stress should be imposed on the instruments or the test piece by the hand, when a reading is being taken. The reading is taken when the pointer has ceased to move.

7. CALCULATION AND EXPRESSION OF RESULTS

7.1 Bulking thickness

7.1.1 Calculate the mean of the readings (not less than 20) and divide by the number of sheets composing each test piece. The value obtained represents the bulking thickness of a single sheet. It is expressed in microns.

7.1.2 Quote the standard deviation of the bulking thickness.**

7.2 Bulk

The bulk is expressed to three significant figures and may be calculated as follows:

$$\text{bulk} = \frac{t}{w}$$

where t = bulking thickness per sheet, expressed in microns,
 w = mass, expressed in grammes per square metre.

8. TEST REPORT

The test report should state

- (a) bulking thickness and standard deviation,**
- (b) bulk as calculated,
- (c) number of sheets and test pieces used for the test,
- (d) number of readings taken,
- (e) mass of the sample, in grammes per square metre,
- (f) any circumstances or influences that may have affected the results.

SPECIAL CASES. In special circumstances, such as for thick or very thin sheets or when agreed upon by manufacturer and consumer, a smaller or larger number of sheets or a smaller or larger size of sheet, may be tested. The actual number and size tested should be reported in the results.

* Speed of about 2 to 3 mm/s.

** The precision of the mean (confidence limits) at the 95 per cent probability level should be quoted for information.

APPENDIX

CALIBRATION OF THE INSTRUMENT

For instruments in frequent use, the calibration should be checked daily for repeatability and accuracy and monthly for parallelism and foot pressure.

For very thin papers, it may be necessary to check the instrument at the same temperature at which it is to be used.

If the instrument is not within the tolerances for any test, it should be corrected before succeeding tests are done.

Checking should be carried out in the following order:

1. **Planarity of foot and anvil.** The pressure foot and the anvil should be carefully wiped and opened slightly so that the gap can be seen against a bright light. The gap should be quite even, when observed in two directions at right angles.
2. **Pressure exerted by the foot.** Any suitable means of checking its accuracy and uniformity may be used.
3. **Repeatability of measurement and determination of indication error.**
 - (a) Set the instrument correctly at zero before commencing.
 - (b) Use a set of feeler gauges of different thicknesses which have previously been checked.
 - (c) Insert these individually between the anvil and the pressure foot and note the corresponding reading on the scale.
 - (d) Check the instrument at approximately 10, 30, 50, 70 and 90 per cent of the full scale reading.
 - (e) A series of at least five readings should be taken at the zero position, followed by at least five readings on each feeler gauge and finally a further set of at least five readings at the zero position.
 - (f) The instrument should not be reset to zero during the procedure.

For each check point on the scale, repeatability of measurement is the standard deviation of the five, or more, readings taken; indication error is the difference between the mean of the five, or more, readings and the feeler gauge thickness.

4. **Parallelism of foot and anvil**

- (a) Insert a feeler gauge on the edge at one side of the pressure foot and note the thickness shown on the scale.
- (b) Insert the same feeler gauge on the edge of the opposite side and note again the thickness shown on the scale.
- (c) Repeat the procedure at right angles to the original position.
- (d) Repeat the procedure with other gauges at approximately 10, 30, 50, 70 and 90 per cent of the full scale readings.

The error of parallelism is defined as half the square root of the sum of the squares of the difference between the opposite readings at the ends of the two perpendicular diameters,

i.e.
$$\frac{1}{2} \sqrt{d_1^2 + d_2^2}$$

where d_1 and d_2 = differences between the measurements at two opposite points.