SLOVENSKI STANDARD
SIST ISO 5628:1995

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Papir, karton in lepenka - Doloļ anje upogibne togosti s statiļ no metodo - Sploģna vodila

Paper and board -- Determination of bending stiffness by static methods -- General principles

Papier et carton -- Détermination de la résistance à la flexion par des méthodes statiques -- Principes généraux

Ta slovenski standard je istoveten z: **ISO 5628:1990**

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85.060	Papir, karton in lepenka	Paper and board

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INTERNATIONAL STANDARD

ISO 5628

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Paper and board — Determination of bending stiffness by static methods — General principles

Papier et carton — Détermination de la résistance à la flexion par des méthodes statiques — Principes généraux

Reference number
ISO 5628:1990(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 5628 was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*.

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Introduction

Bending stiffness is regarded as an important property of paper and board, and a large number of test methods have been used for its determination. This is a result, in part at least, of the wide range of values obtained. For papers and board in a grammage range of 50 g/m^2 to 500 g/m^2, bending stiffness might vary by a factor of over 1 000. This wide variation is reflected in the design of instruments intended for the measurement of this property.

A second factor to be taken into account is that, in general terms, bending stiffness (as defined here) can only be determined with accuracy within certain limitations with regard to the degree of deformation imposed upon the test piece. These limitations depend, in effect, on the dimensions of the test piece and on the test method used.

This International Standard is intended to enable the bending stiffness (as defined here) to be measured and described in a consistent way despite the variations in material type and instrument design. It will be found that many commercially available instruments can be regarded as giving results in accordance with this International Standard for only part of the range of bending stiffness, or for only some of the materials, for which they were originally designed. It is intended, therefore, that this International Standard will be used as the basis for preparing detailed methods for determining bending stiffness, using particular instruments.

Attention is drawn to ISO 5629:1983, *Paper and board — Determination of bending stiffness — Resonance method*, which deals with a dynamic (resonance) method of bending stiffness measurement.

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Paper and board — Determination of bending stiffness by static methods — General principles

1 Scope

This International Standard specifies the general principles to be observed in the preparation of test methods for determining the bending stiffness of all types of paper and board using static methods, by applying line loading to which the mass of the test piece makes negligible contribution.

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 187:1977, *Paper and board — Conditioning of samples*.

ISO 534:1988, *Paper and board — Determination of thickness and apparent bulk density or apparent sheet density*.

ISO 2493:1973, *Paper and board — Determination of stiffness — Static bending method*.

3 Definition

For the purposes of this International Standard, the following definition applies.

bending stiffness, R: The moment of the resistance, per unit width, that a paper or board offers to bending within the limits of elastic deformation. It can be defined mathematically as

$$\frac{EI}{b}$$

where

E is the modulus of elasticity, i.e. Young's modulus;

I is the second moment of area (moment of inertia) of the cross-sectional area, about an axis through the centre of that area, in its plane, and perpendicular to the direction of bending;

b is the width of the cross-sectional area considered.

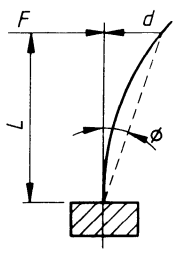
NOTE 1 It is noted that, in the case of multi-ply structures, this definition lacks precision, but for the purpose of this International Standard, it is sufficient to enable measurements to be made.

4 Principle

The bending stiffness of a material, which is proportional to the product of its elastic modulus (E) in the appropriate direction and its moment of inertia (I), can, in practice, be more readily determined as the ratio of the force per unit width applied at right angles to the test piece to the linear deflection that results from the application of this force. Three different loading methods can be considered and these are shown diagrammatically in figure 1 to figure 3. Two point loading is suitable for light materials and three point or four point loading is recommended for heavier materials.

Very flexible paper should be tested with the plane of the test piece vertical.

4.1 Two point loading



The force is applied to the test piece by movement of the deflecting probe.

L is the test length (bending length), i.e. the distance between the top of the clamp and the deflecting probe;

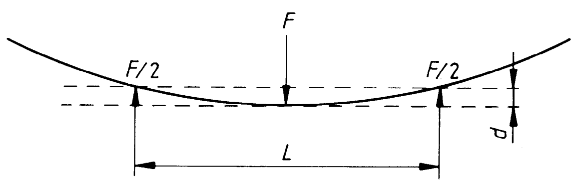
F is the bending force applied through the deflecting probe to the test piece;

d is the deflection and the movement of the deflecting probe;

ø is the arctan (d/L), i.e. the angular deflection.

Figure 1

4.2 Three point loading



The force is applied by movement of the supports relative to a probe located centrally between them.

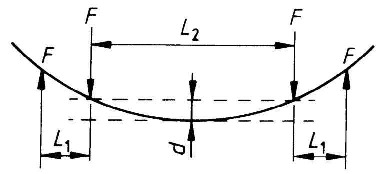
L is the distance between the two supports;

F is the bending force applied at right angles to the test piece and measured by the probe;

d is the deflection of the test piece midway between the supports.

Figure 2

4.3 Four point loading



The force is applied by movement of the outer pair of supports relative to the inner pair of supports.

L_1 is the distance between each outer support and its nearest inner support;

L_2 is the distance between the two inner supports;

F is the force at each of the supports in a direction normal to the undeflected test piece (on most instruments, the force measured will be 2 F);

d is the deflection of the test piece midway between the inner supports, measured from the line through the contact points of the inner supports and the test piece.

Figure 3

5 Apparatus

Any apparatus in accordance with this International Standard shall meet the following requirements.

NOTE 2 The apparatus may consist of an instrument specifically designed to measure bending stiffness or of an attachment or cradle used in conjunction with a suitable tensile tester or compression tester.

It should preferably be of a type that permits continuous recording of the force-deflection curve.

In some two point loading instruments, the bending angle may be measured rather than the linear deflection of the test piece, or a constant bending angle may be used.

In some two point loading instruments, the moment of force ($M = FL$) rather than the force (F) is measured.

5.1 Bending force measurement

The bending force applied shall be measurable to an accuracy of ± 2 % of the reading.

5.2 Deflection measurement

The deflection obtained shall be measurable to an accuracy of ± 2 % and shall not include any distortion of the force applicator.

The deflection indicator, where this is separate from the force applicator, shall not impart to the test piece an additional bending force greater than 1 % of the total bending force.

5.3 Measurement of test lengths

The test lengths L, L_1 and L_2 shall be known to an accuracy of ± 1 % or better because this dimension appears to the third power in calculating the results.

5.4 Deflecting force application rate

The rate of application of the deflecting force (rate of loading) shall not vary by more than 25 % of its maximum during a test.

5.5 Test piece clamps

Clamps (two point loading) shall grip the test piece firmly, but without excessively compressing it, over its full width and shall be at right angles to the length of the test piece.

5.6 Test piece supports and probes

Supports and probes should preferably give effective line contact with the test piece over its full width and shall be at right angles to the test piece. The area in contact with the test piece shall be rounded off to a radius that is appreciably less than the minimum radius of curvature of the test piece during a test. In the case of supports, the radius of curvature of the contacting surface shall be such that the test length does not change by more than 1 % of the undeflected length of the test piece during a test.

NOTE 3 With some instruments the deflecting probe does not contact the test piece over its full width.

6 Limitations on use of instruments

Stiffness measurements should be made over the limited range of deflection for which the load-extension relationship of the material is substantially linear. In those instruments which provide a plot of applied force against deflection, the initial slope of the curve may be used to give the term F/d used in the calculation of results. When the test is performed either by application of a set force and measuring deflection or by measuring the force to produce a set deflection, care must be taken not to exceed the limits of linearity. These limits will vary from material to material. The following limits have been evaluated assuming that linearity may be assumed up to 0,2 % strain. The limit on d_a, the maximum allowable deflection, is directly proportional to this value of limiting strain and so may easily be adjusted for materials where a different value is known.

a) Two point loading

$$d_a = \frac{1{,}3L^2}{t} ; \Phi_a = \frac{76L}{t}$$

b) Three point loading

$$d_a = \frac{0{,}33L^2}{t}$$

c) Four point loading

$$d_a = \frac{0{,}5L^2}{t}$$

where

d_a is the maximum allowable deflection, in millimetres;

L is the test length, in millimetres;

t is the test piece thickness, in micrometres;

Φ_a is the maximum allowable angular deflection, in degrees.

Two further limitations need to be considered in the cases of two point and three point loading. These are

a) Simple bending theory used in the calculation of results assumes that the first derivative of deflection by position is zero at all points in the test piece. This is not strictly true and to keep ensuing errors to less than 5 %, the following limitations need to apply:

1) Two point loading

$$d_a \ngtr 0{,}132L; \Phi_a \ngtr 7{,}5°$$

2) Three point loading

$$d_a \ngtr 0{,}067L$$

b) The effect of shear in the test piece may invalidate the simple bending theory. To keep errors due to this effect below 5 % for both two point and three point loading, the bending length should be at least 40 times the thickness t of the test piece.

Further guidance on limits for deflection, rates of deflection and test piece dimensions will be included in the standards for specific tests.

NOTE 4 The origin of the limiting values given above is contained in the *Handbook of physical and mechanical testing of paper and paperboard*, vol. 1, chapter 7, pp. 323-347, ed. R.E. Mark (Dekker).

7 Sampling

Sample in accordance with ISO 186.