भारतीय मानक
Indian Standard

IS 1060 (Part 5/Sec 8) : 2024
ISO 2493-2 : 2020

कागज़ और संबद्ध उत्पादों के लिए नमूना चयन और परीक्षण पद्धतियाँ

भाग 5 कागज़ और बोर्ड के लिए परीक्षण पद्धतियाँ

अनुभाग 8 बंकन प्रतिरोध का निर्धारण — टेबार-प्रकार टेस्टर

(पहला पुनरीक्षण)

Methods of Sampling and Test for Paper and Allied Products

Part 5 Methods of Test for Paper and Board

Section 8 Determination of Bending Resistance — Taber-Type Tester

(First Revision)

ICS 85.060

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NATIONAL FOREWORD

This Indian Standard (Part 5/Sec 8) (First Revision) which is identical to ISO 2493-2 : 2020 'Paper and board — Determination of resistance to bending — Part 2: Taber-type tester' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Paper and Its Products Sectional Committee and approval of the Chemical Division Council.

ISO has published relevant test method standards under the three broad based titles namely 'Paper, board and pulps', 'Paper and board' and 'Pulps'. To maintain consistency with the prevailing international practices and also to facilitate search of the relevant test methods instantly, all the adopted standards are published under the following two series;

IS 1060 series on 'methods of sampling and test for paper and allied products':

Part 4 Methods of test for paper, board and pulp
Part 5 Methods of test for paper and board
Part 6 Methods of test for paper
Part 7 Methods of test for board

IS 6213 series for 'methods of test for pulps'.

This standard was originally published in 1969 as IS 1060 (Part 3). The test methods, not very commonly used and indented for special purpose, were neither covered by IS 1060 (Part 1) nor IS 1060 (Part 2), had been covered in IS 1060 (Part 3).

Considering the benefits of aligning standards with that of international best practices, in 2014, the Committee decided to revise this standard by identical adoption of ISO 2493-2 : 2011, 'Paper and board — Determination of resistance to bending — Part 2: Taber-type tester' under dual numbering and published it under IS 1060 (Part 5).

During this revision, considering that 2014 version of this standard was identical adoption of ISO 2493-2 : 2011, the Committee decided to further revise the standard by aligning it with ISO 2493-2 : 2020, under dual numbering. During this revision, following changes have been made:

a) Additional data to be reported in **12**; and
b) Several editorial updates.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are however not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

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PART 5 METHODS OF TEST FOR PAPER AND BOARD

SECTION 8 DETERMINATION OF BENDING RESISTANCE — TABER-TYPE TESTER

(First Revision)

1 Scope

This document specifies procedures to measure the bending resistance of paper and paperboard using a Taber-type tester.

This document is used to determine the bending moment required to deflect the free end of a 38 mm wide vertically clamped specimen by 15° when the load is applied at a bending length of 50 mm. For boards that tend to be permanently deformed if bent through 15°, the half bending angle, i.e. 7,5°, can be used. The bending resistance is expressed in terms of the bending moment and parameters set by the manufacturer of the Taber-type tester.

The method is primarily used for papers with a high grammage.

NOTE This document does not cover the low-range version of the Taber-type instrument that uses a bending length of 10 mm (see Reference [5]).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
bending moment
M
torque required to bend a rectangular test piece clamped at one end, measured under the conditions specified in this document

Note 1 to entry: Bending moment is expressed in millinewton metres (mN·m).

3.2
bending resistance
B
mean *bending moment* (3.1) required to bend a rectangular test piece fastened at one end in a clamp, the bending moment being measured under the conditions specified in this document

Note 1 to entry: Bending resistance is expressed in millinewton metres (mN·m).

3.3
bending angle
α
angle through which the clamp rotates while moving from its initial position to the position at which the *bending resistance* (3.2) is measured

Note 1 to entry: The bending angle is 15° or 7,5° (see Clause 10).

3.4
bending length
constant radial distance between the clamp and the position on the test piece at which the force is applied

3.5
bending resistance index
bending resistance (3.2) divided by the grammage to the third power

4 Principle

A test piece of defined dimensions is bent through a specified bending angle (3.3) using a specific type of testing instrument. The resulting bending moment is read from the instrument scale.

For details regarding the test method precision, see Annex A.

5 Apparatus

5.1 Bending resistance tester (see Figure 1), consisting of the following components.

5.1.1 Pendulum, P, rotating around a centre-point, CP, on low-friction bearings, carrying a clamp, C, that has two screws for holding and centring the test piece, TP. At the high end, a centre-line, L, is engraved. At the lower end of the pendulum on its centre-line is a stud, S1, to which weights may be attached and that loads the pendulum at a distance of 100,0 mm ± 0,1 mm from the centre-point. Without added weights, the loading is 10,000 g ± 0,001 g.

5.1.2 Vertical disc, VD, rotating around the centre-point, CP, and driven by a motor, carries two driving arm attachments, DAA, so located as to provide the test piece, TP, with a cantilevered loading length via two driving arms, DA. The bending length (3.4) is 50,0 mm ± 0,1 mm. The driving arms are adjustable by means of screws which enables testing of test pieces of different thicknesses. The ends of the driving arms have rollers as means of transmitting the force to the test piece. It is possible to adjust the length of the arms so that the distance between the test piece and each roller is 0,33 mm ± 0,03 mm.

On the edge of the upper part of the disc, a centre-line mark is engraved. Two reference lines are engraved on the periphery of the vertical disc, VD, at an angular distance of 7,5° and 15° on both sides of the centre-line mark.

A driving mechanism drives the vertical disc, VD, at a nominal constant rate which is allowed to vary between 170° and 210° per minute.

5.1.3 Fixed annular disc, FAD, located around the periphery of the vertical disc, VD. The fixed annular disc has a scale from 0 to 100 on both sides of a centre-line mark, zero. The scale shows the bending

moment required to bend the test piece to the right or to the left (for clarity, only the scale marks 0, 20 and 40 are shown in Figure 1).

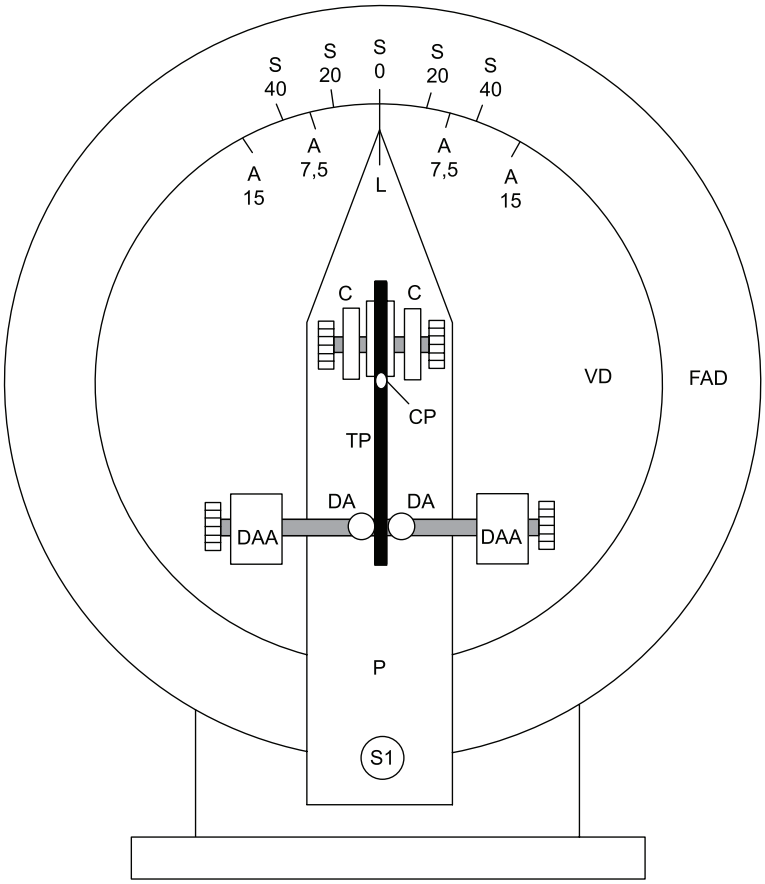
5.1.4 Stand, to support the pendulum, P, the vertical disc, VD, and the fixed annular disc, FAD, equipped with a means for levelling the instrument.

5.1.5 Various loading weights, in stiffness units defined by the manufacturer to be mounted on the stud, S1, to give a maximum bending moment of 490 mN·m.

5.2 Preparation of apparatus

Place the instrument on a firm, flat surface. Set the vertical disc, VD, at zero and place a chosen weight, W, on the stud, S1. Close the clamp, C, so that the faces meet on the centre-line of the pendulum. Level the instrument so that the pendulum is vertical.

Displace the pendulum by 15° and release it to check the bearing friction. It should make at least 20 complete swings before coming to rest.



Key

VD	vertical disc	DAA	driving arm attachments
P	Pendulum	DA	driving arms
TP	test piece	FAD	fixed annular disc
C	clamp	S 0	reference line stiffness 0
CP	centre-point	S 20	reference line stiffness 20
S1	stud	S 40	reference line stiffness 40
A 7,5	reference line, 7,5° deflection	L	centre-line of the pendulum
A 15	reference line, 15° deflection		

Figure 1 — Taber-type tester

6 Calibration

Calibrate the instrument and check the accuracy of the apparatus at regular intervals. The method of calibration depends on the type of instrument and shall be done by following the manufacturer's instructions.

NOTE Spring-steel test pieces are commonly supplied by the manufacturer of the instrument for calibration purposes. Clamps on some instruments are fitted with aluminium faces which are subject to wear. Worn faces change the bending length, producing erroneous results.

7 Sampling

If the tests are being made to evaluate a lot, the sample shall be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces taken are representative of the samples received.

8 Conditioning

Condition the samples of paper or board as specified in ISO 187. Keep them in the conditioning atmosphere throughout the test procedure.

9 Preparation of test pieces

Carry out the preparation of test pieces and the testing in the same conditioning atmosphere as that used to condition the samples.

If the bending resistance index (3.5) is required, determine the grammage in accordance with ISO 536[1].

As required, cut a sufficient number of test pieces, 38,0 mm ± 0,2 mm wide by 70 mm ± 1 mm long, with the length parallel to the machine direction, to enable 5 valid tests to be performed in this direction; and/or cut another set of test pieces with the length parallel to the cross-direction to enable 5 valid tests to be performed in this direction.

Avoid folds, creases, visible cracks or other defects in the area to be tested. If watermarks are present, this shall be noted in the test report.

Highly twisted and curled test pieces may give unreliable results. It is not possible to straighten curled or twisted samples without damaging the material.

10 Procedure

Place a test piece in the clamp, C, with one end approximately level with its top edge and the other end between the rollers at the end of the driving arms, DA.

With the two clamping screws of the clamp, C, align the test piece with the centre-line, L, of the pendulum.

The pressure of the clamping screws may affect the test results. It should be firm enough to hold the test piece, but not so firm as to compress or deform it. The test piece should not be restrained at the free end except by the friction imposed on the surfaces of the free end of the test piece by the driving arms, DA.

Adjust the rollers at the end of the driving arms, DA, so that they are just in contact with the test piece. Adjust the length of one of the driving arms, DA, so that the distance between the test piece and the roller is 0,33 mm ± 0,03 mm.

NOTE 1 It is not necessary for the pendulum to balance at zero with the undeflected test piece in place. Curvature of the test piece will result in a difference between the readings for deflection in the two directions. Readings taken in the two directions are averaged to give the stiffness of the test piece.

Switch on the motor to rotate the vertical disc, VD, to the left and thus deflect the test piece until the centre-line mark, L, on the pendulum is aligned with the 15° mark on the vertical disc VD.

Record the scale reading on the fixed annular disc, FAD, and immediately return the loading disc to zero. Take a similar reading by deflecting the test piece to the right. As required, test at least five machine direction (MD) test pieces and/or at least five cross-direction (CD) test pieces to obtain five valid results, i.e. 10 valid readings, for each required direction.

If the maximum force is obtained before the test piece has been bent through the bending angle 15° (3.3), or a break, kink or crease is observed, the test result should be discarded. If more than 10 % of

the test pieces cut in a particular direction of interest (machine direction or cross-direction) exhibit this behaviour, use a bending angle of 7,5° for this test piece direction. If so, the bending angle shall be reported.

IMPORTANT — The result obtained at a 7,5° bending angle cannot be converted to that of a 15° bending angle by multiplying by two, since the relationship is not directly proportional to the bending angle.

NOTE 2 The tendency for the paper to be deformed in an unacceptable way increases with increasing thickness. The exact thickness for using the bending angle 7,5° cannot be stated.

11 Calculation

11.1 Bending moment

Calculate the bending moment (3.1), M, following the procedure in the manufacturer's manual for the loading weight used.

For each desired direction, machine direction (MD) and/or cross-direction (CD), determine the bending resistance (3.2), B, as the mean bending moment, from all 10 readings (five bending movements to the left, and five bending movements to the right).

Report the bending resistance (3.2), in millinewton metres in the machine direction and/or in the cross-direction, to three significant figures.

NOTE The instruments available report the result in Taber stiffness units. A conversion from Taber stiffness units to SI units can be achieved by using Formula (1) (Reference [4]):

$$M = T_r \times 0{,}098\,066 \tag{1}$$

where

M is the bending moment, in millinewton metres;

T_r is the Taber bending-moment reading, in Taber stiffness units.

11.2 Bending resistance index

If required, calculate the bending resistance index (3.5), B_g for each required principal direction as follows:

$$B_g = \frac{B}{g^3} * 1\,000 \tag{2}$$

where

B_g is the bending resistance index, in micronewton metres times metres to the power six per gram cubed ($\mu Nm \cdot m^6/g^3$);

B is the bending resistance, in millinewton metres (mN·m);

g is the grammage, in grams per square metre (g/m^2) determined in accordance with ISO 536[1].

Report the bending resistance index for each required principal direction to three significant figures.

NOTE The bending resistance index is strictly applicable for test pieces of homogeneous materials, bent through small angles. The bending resistance index is nevertheless useful for a comparison of the bending resistance of papers with small differences in grammage or normalizing the bending resistance to a given grammage. Bending to an angle of 15° usually means there is a higher degree of plastic deformation of the test piece, the higher the grammage. For this reason, the bending resistance index is less useful for higher grammage material and less useful when papers with large differences in grammage are compared in Reference [7].

12 Test report

The test report shall include the following information:

a) a reference to this document, i.e. ISO 2493-2:2020;

b) the date and place of testing;

c) description and identification of the material tested;

d) the type of instrument used;

e) for each direction tested (MD and/or CD), the bending resistance, expressed in millinewton metres, to three significant figures;

f) for each principal direction tested, the standard deviation of the test results;

g) the bending angle used, if other than 15°;

h) if required, the bending resistance index for each required principal direction to three significant figures;

i) any deviations from this document that may have affected the results;

j) the loading weight used.

Annex A
(informative)

Precision

In February 2008, 16 laboratories, from eleven European countries, tested three samples. In total, 10 test pieces were tested. The data has been obtained from CEPI-CTS, the Comparative Testing Service of the Confederation of European Paper Industries.

The calculations were made according to ISO/TR 24498[3] and TAPPI Test Method T 1200 sp-07[6].

The repeatability standard deviation reported in Table A.1 is the "pooled" repeatability standard deviation; that is, the standard deviation is calculated as the root-mean-square of the standard deviations of the participating laboratories. This differs from the conventional definition of repeatability in ISO 5725-1[2].

The repeatability and reproducibility limits reported are estimates of the maximum difference which should be expected in 19 of 20 instances, when comparing two test results for material similar to those described under similar test conditions. These estimates may not be valid for different materials or different test conditions. Estimation of the reproducibility are reported in Table A.2.

Repeatability and reproducibility limits are calculated by multiplying the repeatability and reproducibility standard deviations by 2,77.

NOTE 1 The repeatability standard deviation and the within-laboratory standard deviation are identical. However, the reproducibility standard deviation is NOT the same as the between-laboratories standard deviation. The reproducibility standard deviation includes both the between-laboratories standard deviation and the standard deviation within a laboratory, viz.:

$$s^2_{\text{repeatability}} = s^2_{\text{within lab}} \text{ but } s^2_{\text{reproducibility}} = s^2_{\text{within lab}} + s^2_{\text{between lab}}$$

NOTE 2 $2{,}77 = 1{,}96\sqrt{2}$, provided that the test results have a normal distribution and that the standard deviation s is based on a large number of tests.

Table A.1 — Estimation of the repeatability

Sample	Number of laboratories	Mean value mN·m	Repeatability standard deviation s_r mN·m	Coefficient of variation $C_{V,r}$ %	Repeatability limit r mN·m
Sample level 1[a]	14[b]	49	1,8	3,7	5,1
Sample level 2[a]	16	361	9,4	2,6	26,2
Sample level 3[a]	16	2 565	54,2	2,1	150,2

[a] Level 1, level 2 and level 3 correspond to testing ranges of the Comparative Testing Service of The Confederation of European Paper Industries (CEPI).

[b] Outliers not included.

Table A.2 — Estimation of the reproducibility

Sample	Number of laboratories	Mean value mN·m	Reproducibility standard deviation s_R mN·m	Coefficient of variation $C_{V,R}$ %	Reproducibility limit R mN·m
Sample level 1[a]	14[b]	49	2,8	5,7	7,7
Sample level 2[a]	16	361	22,3	6,1	61,8
Sample level 3[a]	16	2 565	103,1	4,0	285,8

[a] Level 1, level 2 and level 3 correspond to testing ranges of the Comparative Testing Service of The Confederation of European Paper Industries (CEPI).

[b] Outliers not included.

Bibliography

[1] ISO 536, *Paper and board — Determination of grammage*

[2] ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

[3] ISO/TR 24498, *Paper, board and pulps — Estimation of uncertainty for test methods by interlaboratory comparisons*

[4] TAPPI Test method T 489 om-15, *Bending resistance (stiffness) of paper and paperboard (Taber-type tester in basic configuration)*

[5] TAPPI Test method T 566 om-15, *Bending resistance (stiffness) of paper (Taber-type tester in 0 to 10 Taber stiffness unit configuration)*

[6] TAPPI Test method T 1200 sp-07, *Interlaboratory evaluation of test methods to determine TAPPI repeatability and reproducibility*

[7] Fellers C., Carlsson L. Bending stiffness, with special reference to paperboard. In: Mark R.E., Habeger C., Borch J., Lyne B. *Handbook of physical and mechanical testing of paper and paperboard.* Marcel Dekker, New York, Basel, 2002, pp. 233–56

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In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 186 Paper and board — Sampling to determine average quality	IS 1060 (Part 5/Sec 1) : 2014/ ISO 186 : 2002 Methods of sampling and test for paper and allied products: Part 5 Methods of test for paper and board, Section 1 Sampling to determine average quality	Identical
ISO 187 Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples	IS 1060 (Part 4/Sec 1) : 2014/ ISO 187 : 1990 Methods of sampling and test for paper and allied products: Part 4 Methods of test for paper, board and pulp, Section 1 Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples	Identical

In this adopted standard, reference appears to certain International Standards where the standard atmospheric conditions to be observed are stipulated which are not applicable to tropical/subtropical countries. The applicable standard atmospheric conditions for Indian conditions are (27 ± 2) °C and (65 ± 5) percent relative humidity and shall be observed while using this standard.

In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in

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