भारतीय मानक

Indian Standard

IS 4006 (Part 1) : 2024

कागज़ और लुगदी आधारित पैकेजिंग सामग्री — परीक्षण पद्धतियाँ

भाग 1 लचीला प्रतिरोध और विक्षेपण, जलरोधी, जल प्रवेश, तेल प्रतिरोध, घर्षण हानि, अवरुद्ध प्रतिरोध, संपीड़न प्रतिरोध और कठोरता, अकड़न और कोमलता

(दूसरा पुनरीक्षण)

Paper and Pulp Based Packaging Materials — Methods of Test

Part 1 Flexural Resistance and Deflection, Waterproofness, Water Penetration, Grease Resistance, Abrasion Loss, Blocking Resistance, Compression Resistance and Rigidity, Stiffness and Softness

(Second Revision)

ICS 85.060; 85.080

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Paper Based Packaging Materials Sectional Committee, CHD 16

FOREWORD

This Indian Standard (Part 1) (Second Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Paper Based Packaging Materials Sectional Committee, had been approved by the Chemical Division Council.

The packaging should be adequate to protect the contents from several hazards like the vagaries of climate, rough handling, indifferent transport methods and the system of marketing and storage.

The packaging materials as are used in the industry are many and varied. They are paper and paper products, textiles, metal and metal foils, plastics and a variety of laminates, wood, glass and ceramics, cushioning materials, strapping and hooping materials, nails, etc. Among these, paper and paper products are of major importance.

This standard (Part 1) of IS 4006 series of standards which cover methods of tests which are carried out for paper and pulp based packaging materials to evaluate their quality. Other parts of IS 4006 series are:

Part 2 Odour, ply separation, puncture, and reducible sulphur

Part 3 Arsenic, total copper, total iron, water soluble copper and water soluble iron

This standard was first published in 1966. It was first revised in 1985, in the light of latest technological developments. In the first revision, compression resistance (ring crush test) and air permeance test was aligned with international methods of testing. An alternate test method by Taber stiffness tester for the measurement of rigidity, stiffness and softness was prescribed.

While carrying out second revision of the standard, the committee responsible for development of this standard observed that IS 1060 (Part 5/Sec 11) : 2021/ISO 5636-3 : 2013 ‘Method of sampling and test for paper and allied products: Part 5 Method of test for paper and board, Section 11 Determination of air permeance (medium range) — Bendtsen method’ has already been developed for air permeance given in this standard by adopting ISO standard under dual numbering. Additionally, BIS has formulated two more standards namely IS 1060 (Part 5/Sec 13) : 2021/ISO 5636-4 : 2013 ‘Paper and board — Determination of air permeance and air resistance (medium range): Part 5 Method of test for paper and board, Section 13 Sheffield method and IS 1060 (Part 5/ Sec 14) : 2014/ISO 5636-5 : 2013 ‘Methods of sampling and test for paper and allied products; Part 5 Methods of test for paper and board, Section 14 Determination of air permeance and air resistance (medium range) — Gurley method. The committee, therefore, decided to revise this standard by deleting the above test method from this standard as more updated test method standard is available. Further, a title has been specified covering the test methods and reference clause has been updated, too.

The composition of Committee responsible for formulation of this standard is given in Annex A.

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

Indian Standard

PAPER AND PULP BASED PACKAGING MATERIALS — METHODS OF TEST

PART 1 FLEXURAL RESISTANCE AND DEFLECTION, WATERPROOFNESS, WATER PENETRATION, GREASE RESISTANCE, ABRASION LOSS, BLOCKING RESISTANCE, COMPRESSION RESISTANCE AND RIGIDITY, STIFFNESS AND SOFTNESS

(Second Revision)

1 SCOPE

This standard prescribes methods for the following tests for paper and pulp-based packaging materials:

a) Flexural resistance and deflection;

b) Waterproofness;

c) Water penetration;

d) Grease resistance;

e) Abrasion loss;

f) Blocking resistance;

g) Compression resistance; and

h) Rigidity, stiffness and softness;

2 REFERENCES

The standards given below contain provisions which, through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards:

IS No.	*Title*
IS 1060 (Part 1) : 2022	Methods of sampling and test for paper and allied products: Part 1 Test methods for general purpose (*second revision*)

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Air Permeance — The mean flow of air through unit area under unit pressure difference in unit time, under specified conditions. It is expressed in micrometers per pascal second. [1 ml/(m^2.Pa.s) = 1 µm/(Pa.s)].

3.2 Blocking — Blocking is defined as the degree of cohesion or adhesion between contiguous layers of similar or dissimilar materials in roll or sheet form which prevents their satisfactory and efficient use.

3.2.1 *Blocking Resistance* — The ability of a given material to resist blocking effects of temperature, pressure and the relative humidity.

3.3 Density — The mass of paper or paperboard per unit volume or the apparent specific gravity.

3.4 Rigidity or Flexural Resistance — The property of a paper or paper board to resist an applied bending force proportional to *EI*, where *E* is Young's modulus and *I* is the moment of inertia.

3.5 Rigidity Factor — It is proportional to the modulus of elasticity, *E*, or modulus of rigidity which is a measure of the rigidity of the structure of the sheet; it is a specific property of the material and the way it is put together inside the sheet.

3.6 Softness — Softness of a paper is the feeling of softness when a sheet is crumpled in the hand. This depends upon the ease of crumpling, together with the absence of sharp edges in the crumpled sheet. It is inversely proportional to the rigidity *EI* modified by a function of the thickness of the sheet.

3.7 Stiffness — Ability of paper or paperboard to support its own mass, the inverse of flabbiness or limpness. It is proportional to *EI/M* where *M* is the nominal mass of the paper or paperboard.

3.8 Stretch — The extension resulting from the application of a tensile stress up to the point of rupture.

3.9 Tensile Strength — The limiting resistance of a test piece of paper or board submitted to a breaking force applied to each of its ends under the conditions defined in the standard method of test. The tensile strength is generally expressed as breaking length.

3.10 Thickness — It is the thickness of a single sheet when placed under steady pressure of 0.5 kg/cm^2 to 0.6 kg/cm^2 between two circular and parallel plane surfaces, the smaller of which has an area of approximately 160 mm^2.

4 SAMPLING

Representative samples for test shall be drawn as prescribed in IS 1060 (Part 1).

5 CONDITIONING OF TEST SPECIMENS

Since the relationship between the moisture content of the material under test and the results of various tests varies, the material under test shall be conditioned as given in IS 1060 (Part 1).

6 FLEXURAL RESISTANCE AND DEFLECTION

6.1 General

This test indicates the relationship between the load and deflection which may be used to determine the modulus of elasticity or stiffness of a given paper product. This test is usually used for book binding papers.

6.2 Apparatus

6.2.1 *Tensile Tester*

Preferably equipped with a recording device which gives a graphic record of the applied load and deflection (*see* note under **6.2.2.2**).

6.2.2 *Flexural Loading Device*

6.2.2.1 This is in two parts. The stirrup is provided with a tab for clamping in the upper clamp of the tensile tester. The bearing surface at the bottom of the stirrup is a smooth metal cylinder. The stressing attachment carries an inverted stirrup at each end, similar to stirrup mentioned above, such that the cylinders are parallel to each other, and a tab in the centre to be clamped in the lower (stressing) clamp of the tensile tester.

6.2.2.2 The span (distance between centres of the two cylinders in attachment) shall be 75 mm and the diameter of the cylinders shall be 3 mm.

NOTE — Any equivalent means of applying a measurable load to the centre of supported strip of the specimen and measuring the deflection may be used.

6.2.3 *Scale*

If the tensile tester or other apparatus used is not equipped with a device for recording the deflection it may be measured with a scale graduated in 0.01 cm.

6.3 Test Specimen

The test specimens shall be cut from the sample in such a way as to be thoroughly representative of it. The test specimens shall be 125 mm long and 25 mm wide, cut accurately and parallel to within 1.5 mm and with clean-cut edges in each principal direction of the sample. The specimens shall be conditioned for testing as a given in **5**.

6.4 Procedure

6.4.1 Fasten attachment in the lower (stressing) clamp of the tensile tester with the axes of the two cylinders in a plane perpendicular to the direction of movement of the clamp. Fasten stirrup in the upper clamp with its cylinder parallel to the other two so that it will load the specimen at mid span. Counterweigh the stirrup or determine the scale correction necessary to compensate its mass. Run up the lower clamp with the attachment until the specimen is insertable without bending under the two end cylinders and over the one of mid span, leaving equal lengths projecting at the two ends. Apply the load until the specimen breaks or until after a maximum load has been reached. The rates of loading shall be such that the maximum is reached between 30 s and 45 s.

6.4.2 If the testing instrument does not have a recording device for the amount of deflection at maximum load, measure it with the scale. Allow one end of the scale to rest on the lower clamp and read the scale opposite a reference line on the upper clamp at the instant loading is begun, at chosen intervals of loading, and at the instant of failure or maximum load.

6.4.3 Tests shall be made on not less than 5 specimens cut from each of the two principal directions of the sample.

6.5 Report

6.5.1 Report the results to two significant figures as the average flexural resistance (load at failure, or maximum load in case there is no failure) in kilograms, and the deflection in millimeters in both principal directions of the sample for the dimensions of the specimen tested.

6.5.2 The report may also give the load corresponding to various increments of deflection or the deflection at various load increments.

7 WATERPROOFNESS

7.1 General

Waterproofness of the outer surface is determined by exposing a known area of paper or board to 2.5 cm head of water for 30 min and finding the increase in mass.

7.2 Apparatus

It consists of two square metal plates having a circular opening in the centre with an area of

approximately 80 cm^2. A suitable type of apparatus is shown in Fig. 1.

7.3 Procedure

Fix the weighed sample in the tester and put water at 27 °C ± 2 °C on its surface to form a head of 2.5 cm. After 30 min have elapsed, decant the water and remove the surface water quickly with the help of blotting paper. Again weigh the sample without any loss of time. Minimum 3 samples shall be tested.

7.4 Calculation

Report the average increase in mass of the 3 samples tested as follows:

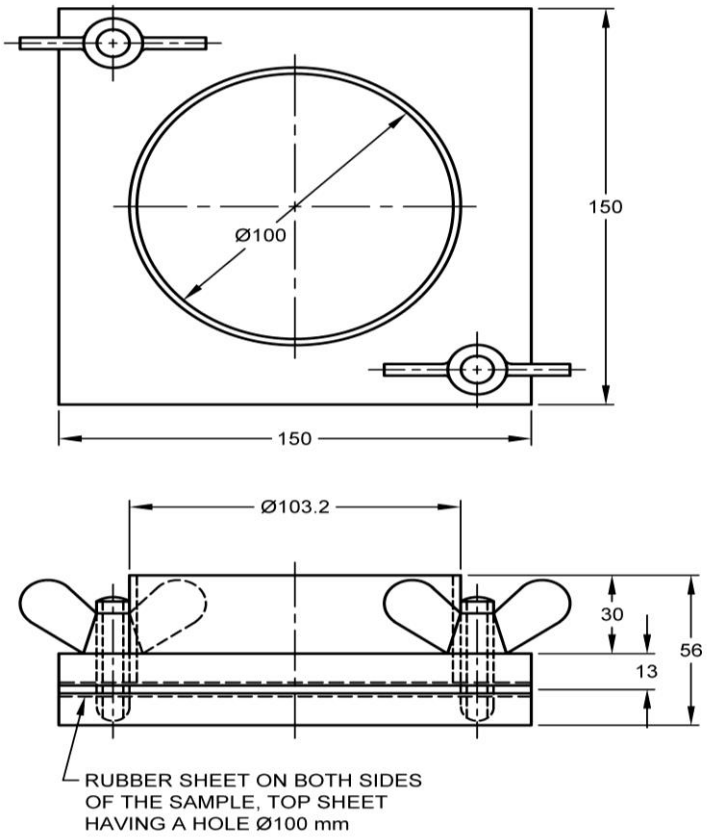
$$\text{Increase, g/m}^2 = \frac{M_2 - M_1}{A}$$

where

M_2 = mass, in g, of the sample after exposure to water;

M_1 = initial mass, in g, of the sample; and

A = area, in m^2, of the sample.



All dimensions in millimetres.

FIG. 1 APPARATUS FOR THE DETERMINATION OF WATERPROOFNE

8 WATER PENETRATION

8.1 Apparatus

It consists of a metal tube with an internal cross-section of not less than 10 cm^2 and not less than 10 cm high, with arrangements to clamp it on the test piece.

8.2 Procedure

Clamp the metal tube on the sample, placing a filter paper in close contact with it on the underside of the sample. Put water at 27 °C ± 2 °C containing one percent eosin or any other water soluble dye. At the end of 18 h pour out the water and examine the filter paper underneath. There should be no staining of the filter paper.

9 GREASE RESISTANCE

9.1 General

Grease resistance of paper is determined by the time taken by turpentine to penetrate through the paper.

9.2 Apparatus

9.2.1 Tube of any rigid material, 2.5 cm inside diameter and not less than 2.5 cm in height, with smoothened ends.

9.2.2 *Pipette* — calibrated to deliver 1.1 ml

9.2.3 *Round-Grained Sand* — screened to pass a 850 µm IS sieve and be retained on a 600 µm IS sieve.

9.2.4 *Paper* — sheets of clay coated white papers of 100 g/m^2 substance.

9.3 Reagents

9.3.1 *Turpentine* — coloured, water-free turpentine, prepared as follows.

9.3.1.1 To 100 ml of pure gum spirits turpentine (relative density 0.860 to 0.875 at 15.5 °C) add 5 g of anhydrous calcium chloride and 1.0 g of oil-soluble red dye. Stopper the container, shake well and let stand for at least 10 h. Shake occasionally. Then filter through a dry filter paper and store in an air-tight bottle.

9.4 Test Specimen

Cut representative specimens 10 cm square from the sample under test.

9.5 Procedure

9.5.1 Not less than 10 conditioned specimens shall be used. Make an equal number of tests on each side of the sample; if possible, note which is the felt side and which is the wire side.

9.5.2 Place each specimen on a sheet of the paper, which rests on a smooth plane surface. Place the end of the tube on the specimen and put 5 g of sand in the tube. Since the purpose of the tube is solely to assure a uniform area of the sand pile, remove it immediately after the addition of the sand. Using the pipette add 1.1 ml of the coloured turpentine to the sand and note the time.

9.5.3 Move the test specimens to different positions on the paper and examine the uncovered area of it for staining, every 30 s for the first 2 min, every minute for the next 8 min, and every 3 min thereafter. As soon as the first red stain appears on the paper, note the time. The time elapsed, in seconds, between the application of the turpentine and the appearance of the first distinct red stain shall be recorded as the transudation time.

NOTE — In the absence of knowledge of the probable time of transudation, it is advisable to make a few preliminary tests.

9.6 Report

9.6.1 Results shall be reported as turpentine transudation in terms of seconds. The report shall include the number of specimens tested and the maximum, minimum, and average turpentine transduction. If it is possible to identify the two sides of the paper, results shall be reported separately for specimens tested with the felt side up and with the wire side up. All tests over 1 800 seconds shall be reported as 1 800 + seconds and if individual results of 1 800 + are included in any average, such average shall be followed by a plus sign. The average shall be reported on the basis of all tests made. It is recommended that the following form be used in reporting results when possible:

	Felt Side Up	*Wire Side Up*
Turpentine transudation, seconds:		
Maximum	1 800 +	1 750
Minimum	1 500	1 400
Average of 10 tests	1 750 +	1 600
Total average	1 675 +	—

10 ABRASION LOSS

10.1 General

This method provides a measurement of the susceptibility of the surfaces of paper and

paperboard used for packaging to the action of standardized abrasive surfaces, either wet or dry. The test gives indication of the surface wear to be expected when packages are shipped and subjected to prolonged vibration in contact with each other. It is not applicable to surfaces which are waxed or treated with similar materials that would fill in the pores of the abrasive wheels.

10.2 Apparatus

10.2.1 *Abrading Instrument*

It consists of a horizontal turntable and centre clamp which revolves counter-clock wise at 65 rpm to 75 rpm, upon which the specimen is attached, and two weighted parallel arms, each carrying a special abrasive embedded rubber wheel freely rotating on a ball-bearing horizontal spindle on each arm, and each resting on the specimen with a pressure of 1 000 g for the dry test and 500 g for the wet test. The surface of the table is covered with a disk of soft, rubberized material 0.75 mm thick. Each abrasive wheel is 4.5 cm to 5 cm in diameter and 12.7 mm thick and is composed of a special finely screened and standardized abrasive embedded in hard rubber. A revolution counter is attached to the table.

10.2.1.1 The lines of contact of the wheels on the specimen are at right angles to the parallel supporting arms and situated at 2.5 cm from the centre of the turntable towards the axis about which the supporting arms turn. The centre of the line of contact of the wheel on the arm to which the turntable revolves is 4.5 cm to the right of the perpendicular from the axis of the arms to the centre of the turntable. The centre of the contact line of the wheel on the arm from which the turntable revolves is 39 mm to the left. In this manner, when in contact with the turning specimen, the two wheels revolve in opposite directions and exert a combined abrasive, compressive, and twisting action over a circular path approximately 10 cm^2 in area, twice during each revolution of the specimen.

10.2.1.2 For the wet abrasion test, use a rubber-covered turntable having and annular raised rim, to permit the surface of the specimen to be covered with water during the test.

10.2.2 *Resurfacing Turntable*

A rubber-covered turntable on which an abrasive disk is mounted, for resurfacing the wheels.

10.2.3 *Brush*

A soft brush about 12.5 mm wide with the bristles protruding about 25 mm.

10.3 Calibration

10.3.1 After testing a fibre surface containing fillers or coating, or after each 1 000 revolutions, re-surface the wheels as given in **10.3.1.1**.

10.3.1.1 With the resurfacing table and disk in position, run the wheels on the surface under pressure of 1 000 g for 20 cycles to 50 cycles, depending on their condition. During the resurfacing operation, continually remove abraded particles from the wheels and disk by blowing or with the brush. Renewal of the wheel faces is indicated by the clearing up of the initial coloured track on the abrasive disk.

10.4 Test Specimens

10.4.1 Three or more square, octagonal, or circular conditioned specimen disks, approximately 100 cm^2 in area, with a hole in the centre to permit clamping on the turntable, are required. For paperboards more than 3 mm thick, especially for the wet test, it may be necessary to split or suitably reduce the thickness of the specimens, taking care not to affect the surface to be tested.

10.4.2 Unless it is specified which side of the specimen is to be tested, mark the sides A and B, respectively, and report results for each side separately.

10.5 Procedure

10.5.1 *Dry Abrasion Test*

Carefully brush the surface and edges of each test specimen, holding it by the edges. Weigh to the nearest milligram and clamp it in position on the turntable. Reset the counter at zero and carefully lower the wheels on the specimen with a pressure of 1 000 g. Start the test by switching on the motor. Allow the test to proceed for a sufficient length of time so that the surface of the test specimen is just completely removed. Meanwhile with the brush but not by blowing, remove accumulated debris from time to time. Note the counter reading remove the test specimen and holding it by the edges, carefully brush off any loose fibres or particles and reweigh. Record the loss in mass in milligrams L.

10.5.2 *Wet Abrasion Test*

10.5.2.1 Thoroughly clean the rimmed turntable and mount the specimen to be tested. Adjust the mass of the arms to 500 g each and lower them upon the specimen. Reset the counter to zero. Add sufficient water at room temperature to flood the upper surface of the specimen and immediately switch on the motor. Allow the test to proceed for a sufficient

length of time so that the surface of the test specimen is just completely removed. During this test, neither use the brush nor disturb the action of the wheels. Note the counter readings.

10.5.2.2 Remove the rimmed table and pour off the liquid into a clean beaker or glass dish. Remove the specimen and, with a wash bottle or gentle jet of water, wash all the loose material from the surface of the specimens and from the inside of the turntable into the dish and add also any fibrous particles adhering to the wheels.

10.6 Calculation and Report

10.6.1 The abrasion loss is defined as the number of milligrams of material removed per 1 000 revolutions calculated from the formula:

$$\text{Abrasion loss} = \frac{1\,000\,L}{R}$$

where

L = material removed in milligrams; and

R = number of revolutions of the turntable.

10.6.2 Report the average result from a specified side of at least 3 specimens as the abrasion loss to the nearest two significant figures.

11 BLOCKING RESISTANCE

11.1 General

This method covers the test for rating the blocking resistance of flexible types of packaging materials wherever the tendency to block is important. The blocking resistance is determined by observing the adhesion or cohesion between the contiguous surfaces of the specimens when they have been subjected to a pressure of 35 g/cm^2 for a period of 24 h.

11.2 Apparatus

11.2.1 *Oven*

A constant-temperature oven which is capable of maintained at selected temperatures from 27 °C to 67 °C within ± 1 °C.

11.2.2 *Desiccator* (*for Use as Humidity Chamber*) — *minimum* diameter 152 mm. Ground glass edges should be perfect, clean and freshly lubricated with stopcock grease.

11.2.3 *Bedplate* — 10 cm × 10 cm piece of plate glass or metal plate with flat upper surface.

11.2.4 *Pressure Blocks* — four blocks or suitably weighed pieces of plate glass with flat under surfaces 35 mm x 45 mm. The mass of each block or weighed glass surface shall be adjusted to yield a pressure of 35 g/cm^2 on underlying specimens.

NOTE — A brass block in the form of a rectangular parallelopiped, 35 mm × 45 mm × 45 mm approximately will meet the requirements without loading. The height of the block should be adjusted to give a total mass of 551.25 g.

11.2.5 *Interleaving Material* — thin, hard surfaced paper or metal foil 35 mm × 45 mm.

11.3 Test Specimens

Eight test specimens each 35 mm × 45 mm shall be cut from each sample for each set of test conditions used. The specimen shall be cut from the samples in such a way as to be fully representative.

11.4 Test Conditions

11.4.1 One or more of the sets of conditions given below shall be used to test for blocking. Selection of the proper conditions will depend upon the type of material tested and the actual conditions which are liable to arise during storage and use of the material. In any case the temperature selected shall be below the softening point of the coating. (If the test temperature used is higher than the softening point of the coating materials, such as wax, these may soak into the base sheet and thus give no adhesion):

Sl. No.	*Dry Bulb Temperature* °C	*Relative Humidity* Percent	*Pressure* g/cm^2
(1)	(2)	(3)	(4)
i)	38	75	35
ii)	49	75	35
iii)	60	75	35
iv)	38	44	35
v)	49	44	35
vi)	60	44	35

NOTE — A tolerance of 1 °C is allowable in the temperatures listed.

11.4.2 The desired relative humidity condition is obtained by using a saturated solution of the proper salt in distilled water in the presence of an excess of the solid phase. Place the solution in the base of the desiccator for this test using sodium chloride to achieve 75 percent relative humidity and potassium carbonate to obtain 44 percent relative humidity.

11.5 Procedure

11.5.1 Condition the test specimens for at least 1 h prior to test under the conditions specified in 5. Also condition the apparatus including the desiccator containing the proper salt solution and the pressure surfaces after assembly, for at least 1 h in the test oven which has been previously adjusted to the desired temperature. When the desiccator is warmed, open its lid for a few minutes and then close the lid until the specimens are ready for insertion.

11.5.2 Stack the conditioned test specimens and pressure media on the shelf of the desiccator in the following sequence:

a) 10 cm × 10 cm bottom plate;

b) Interleaving paper of foil;

c) Four test specimens;

d) Interleaving paper or foil;

e) Four test specimens; and

f) Pressure block.

11.5.3 Stack specimens having faces of different characters so that the three possible surface combinations, namely, face to face, face to back, and back to back, are tested. In this case, stack the two sets of 4 test specimens in the following sequence:

Interleaving paper or foil

One specimen, face up
One specimen, face down } (face to face)

One specimen, face down
One specimen, face up } (back to back)

Interleaving paper or foil

One specimen, face up
One specimen, face down } (face to face)

One specimen, face down
One specimen, face up } (back to back)

Interleaving paper or foil

Pressure block

11.5.4 A desiccator 15 cm in diameter permits 4 samples to be tested in duplicate at one time. Locate each stack in a quarter section of the bottom plate so that individual stacks do not overlap and so that the test areas are completely supported by the bottom plate.

11.5.5 Place the desiccator containing the assembled test stacks in the oven. Let the lid of the desiccator remain partially open for 15 min, then slide it shut. Leave the desiccator in the oven at the desired temperature for 24 h ± 1 h. Then take the desiccator from the oven, carefully remove the pressure blocks from the test stacks and remove each stack from the desiccator. Gently lay the stacks of test specimens down in the room preferably at 27 °C and 65 percent relative humidity, for half an hour, then examine by slipping or peeling the sheets apart and rate for blocking resistance as given below:

Sl. No.	*Blocking Resistance*	*Criteria*
(1)	(2)	(3)
i)	No blocking	No adhesion or cohesion between contiguous surfaces, which slide freely upon one another. Surfaces of specimens are not marred when sheets are separated.
ii)	Slight blocking	Slight adhesion. Adjacent surfaces do not slide freely, but with frictional pressure. Surface may or may not show a very slight evidence of marring
iii)	Considerable blocking	Adhesion or cohesion of contiguous surfaces. Layers may be separated with difficulty. Surfaces will be marred or partially destroyed. Paper-base materials show loss of fibre. Synthetics may or may not display surface mar
iv)	Complete blocking	Blocking to the extent of a complete seal or weld between adjacent surfaces which cannot be separated without destruction of the testspecimen

11.6 Report

The report shall include the name and type of material, the rating of blocking resistance, including a brief description of blocking found, the temperature, relative humidity and pressure used. If dissimilar surfaces exist on the test specimen, report the blocking of the 3 possible surface combinations.

12 COMPRESSION RESISTANCE (RING CRUSH TEST)

12.1 General

This method covers the measurement of the resistance of paperboard to edgewise compression. Corrugated and solid fibreboard containers are subjected to crushing forces in shipment. This test is used for two purposes in the evaluation of the paperboard to be used as components of such fibreboard containers: (a) to indicate edgewise rigidity of the board so that manufacturing processes may be controlled to secure the desired results, and (b) to indicate the probable crushing resistance of the finished container. This method is intended only for paperboard not exceeding 0.49 mm in thickness.

12.2 Apparatus

12.2.1 *Compression Machine*

The apparatus shall consist essentially of a compression testing machine having the following.

12.2.1.1 An upper and a lower platen, one of which may be fixed and the other removable. The surfaces of the platen shall remain smooth, flat, and parallel to each other within 1 part in 2 000 throughout the test and shall be so mounted as not to have more than 0.05 mm movement in the horizontal direction.

12.2.1.2 Means for exerting force on a specimen placed between the two platens. This may be accomplished either by causing the movable platen to approach the fixed platen at a uniform speed or applying a constantly increasing pressure against the movable platen without necessarily causing motion thereof until collapse of specimen. In either case, the force applied to the specimen shall be developed at a rate equivalent to (111 N ± 22 N) when the platens are in contact. Means for measuring and indicating the applied load within 4.4 N and the machine should have a capacity of not less than 1 330 N and the indicating mechanism should be such that it can be accurately checked with dead-weight loads.

12.2.1.3 *Specimen holder*

At the centre of the lower platen of the compression testing machine there shall be positioned a specimen holder comprising a circular block having an annular groove cut square 6.4 mm ± 0.2 mm deep and 49.3 mm ± 0.03 mm in outside diameter. The base of the annular groove shall be parallel with the base of the block to 0.013 mm. A branch groove running from the annular groove to the edge of the block shall be provided to permit insertion of the specimen. The centre "island" created by the annular groove may be made removable and replaceable with disks of different diameters so as to vary the width of the groove to provide for varying specimen thickness. The disk used for any particular caliper of board shall be of such a diameter that when placed in the block the resulting groove will have a width not less than 150 and not more than 175 percent of the nominal caliper of the specimen being tested. The table given below may be utilised for the selection of the proper disk for a particular test. These disks may be provided with a centre pin to fit a receiving hole in the centre of the block. The disk is then free to turn as the specimen is inserted through the branch groove. While this is the preferred design any specimen holder which provides support to both surfaces of the specimen permits 6.4 mm of the specimen to extend above the surface of the holder, and allows insertion without injury to the specimen, is acceptable:

Sl No.	*Thickness of Test Piece*	*Diameter of Disk*
	mm	mm
(1)	(2)	(3)
i)	0.15 to 0.17	48.80
ii)	0.17 to 0.20	48.70
iii)	0.20 to 0.23	48.60
iv)	0.23 to 0.28	48.50
v)	0.28 to 0.32	48.30
vi)	0.32 to 0.37	48.20
vii)	0.37 to 0.42	48.00
viii)	0.42 to 0.49	47.80

12.2.2 *Cutting Device*

A device capable of accurately cutting the specimen to exact dimensions. The edges of the specimen must be clean and sharp and absolutely parallel. The preferred method of accomplishing this is by means of a punch and die, or, lacking this, a card cutter equipped with an adjustable outside guide. Parallelism of the long edges of the specimen shall be such that the width dimensions at the opposite ends shall be within 0.015 mm of each other. The length shall be 152 mm ± 0.13 mm.

12.3 Test Specimen

All test specimens shall be 152 mm long and 12.7 mm wide. Those cut with the long dimension perpendicular to the machine direction of the board shall be designated MD specimens; those cut with the long dimension parallel to the machine direction of the board shall be designated CD or OD specimens. At least ten specimens of each of these two directions shall be cut and tested. In cutting the specimens, care shall be exercised to assure that.

12.3.1 The long edges are parallel such that the width at opposite ends shall be within 0.015 mm of each other.

12.3.2 The ends will just about cover, and not overlap or leave a gap when placed in the specimen holder.

12.3.3 The long edges are truly parallel (or perpendicular) to the machine direction of the board.

12.3.4 The long edges are cut clean without wipe or being torn or frayed in any way by poorly functioning cutting equipment.

12.4 Procedure

Insert each specimen in the specimen holder and position at the centre between the two platens. When inserting the specimens in the specimen holder, they shall be alternated in such a manner that half of the specimens are tested with the finished surface of the board on the convex side and half with the finished surface on the concave side of the ring.

Apply the crushing force to the long edges of the specimen ring until the 6.4 mm section projecting above the specimen holder has collapsed. Record the maximum load required to cause this collapse.

12.5 Report

Report the average load required to crush the sample, in each direction, in kilograms to the nearest 0.1 kg. State whether the crushing force is developed by means of a constant speed movable platen or by the application of a constantly increasing pressure to the movable platen.

13 RIGIDITY, STXFFNESS AND SOFTNESS

13.1 General

The measurement of rigidity, stiffness and softness helps in predicting the performance of a packaging material in actual use. Two methods have been prescribed for the determination of stiffness. Method A is meant for paper or light weight paper board and Method B is for paper board only.

13.2 Method A

13.2.1 *Apparatus*

13.2.1.1 The apparatus used shall consist of a clamp formed by a pair of flat jaws or rollers adapted to grip the end of a 50 mm wide strip of material to be tested along a horizontal axis at right angles to its length. The jaws or rollers shall be mounted on a spindle so as to enable the clamped end of the strip to be rotated about that axis and means shall be provided for indicating when the clamped end of the strip has been rotated axially through a right angle from any initial position. Clamping surfaces shall be coincident. The edges of the clamping surfaces shall be coincident.

13.2.1.2 When determining the critical angle of sheet materials that creep appreciably during the interval between reversals during the test (for example, paper coated with plastic waxes and textiles), stops shall be used on either side of the spindle which are so positioned as to catch the specimen near its end as it falls over, but not high enough to lend any support to the specimen when the spindle is reversed to the position where the specimen is about to fall back to the other side. These stops may be coveniently made from to strips of bent thin sheet copper fixed to the base of the instrument.

13.2.1.3 Before use, the instrument shall be levelled so that the axis of the clamping edges is horizontal.

13.2.1.4 Rule accurately graduated in millimetres.

13.2.1.5 Scale for accurately determining the nominal substances.

13.2.1.6 Standard thickness micrometer.

13.2.2 *Test Specimen*

The specimens for test shall be cut with clean and parallel edges in each principal direction of the paper, 15 mm to 50 mm wide, and over 75 mm or as long as may be convenient. Eliminate any pronounced curvature of the strips in the direction of

their length by rubbing the strip over a smooth edge before testing. Also eliminate in a similar way any curvature across the width of the strips before cutting. In such cases the width of the cut strips should be reduced to the minimum namely 15 mm.

13.2.3 *Procedure*

Place the end of each strip between the jaws of the spindle and with enough overhanging length so that on rotating the spindle clockwise, the strip being on the left, falls through the vertical to the right, and on rotating the spindle counter-clockwise, it does not fall back to the left when turned through 90" from that point. Reduce the overhanging length until a slow rotation of 90 °C ± 2 °C clockwise and counter-clockwise causes the end of the strip to fall from one side to the other. Measure the effective overhanging length (critical length) from the line where the edges of the jaws or rollers grip the specimen to the end of the strip. With rollers, a little dry carbon black or dyestuff may be blown into the nip to locate accurately the grippping edge and enable a corresponding mark to be made on the framework to serve as a datum for test made thereafter.

13.2.4 *Report*

The report shall state, as may be required, the rigidity, rigidity factor, stiffness, or softness in each direction to 3 significant figures calculated as follows:

$$\text{Rigidity} = \frac{L^3\, M}{10\,000}$$

$$\text{Rigidity factor} = \frac{16.4 \times L^3 \times M}{100 \times T^3}$$

$$\text{Stiffness} = \frac{L^3}{100}$$

$$\text{Softness} = \frac{1\,000\,000 \log\left(\frac{t}{2.54}+1\right)}{L^3\, M}$$

where

L = average critical length in cm;

T = thickness of a single sheet of paper in thousandths of centimetre;

T = basic thickness of a single sheet of creped paper in thousandths of centimetre; and

M = nominal mass of the paper or paperboard in g/m^2.

13.3 Method B

13.3.1 *Apparatus*

13.3.1.1 *Stiffness instrument*

The apparatus used shall consist of a pendulum supported in antifriction bearings, carrying a vice which has two clamping screws for holding and centering the test specimen, the lower edge of the vice coinciding with the centre of the pendulum bearing. The pendulum is balanced, and at its lower end is a stud to which weights may be attached, and which loads the pendulum at a distance of 100 mm from its centre; without added masses of counter masses the loading is 10 g. A line, coinciding with the centre line of the vice jaws and the weight stud, is engraved at the upper end of the pendulum.

13.3.1.2 A vertical disk, driven on the same axis as the pendulum by a geared reversible electric motor at the rate of (210 ± 20) per minute carries two driving arm attachments so located as to provide the specimen with the cantilevered loading length of 50 mm when it is deflected 15°. The driving arms have rollers which are adjustable to accommodate specimens of different thickness. In the periphery of the upper part of the disk is a marked line coinciding with the centre line between the driving rollers and the axis, and two reference lines are engraved on the periphery of the disk at angular distances of 7.5° and 15° on both sides of the centre mark.

13.3.1.3 Located around the periphery of the disk, a fixed annular disk with a load scale from 0 to 100 on both sides of a zero point which is adjusted to coincide with the centre line mark, the scale indicating the bending moment required to flex the specimen to the right or to the left, the divisions being in accordance with the sine of the angle through which the pendulum and weight are turned.

13.3.1.4 A switch for the motor to turn the disk clockwise or counterclockwise and which preferably also operates an electric brake to stop the disk at any point on the scale. Bending moment of 5 000 g cm.

13.3.2 *Test Specimen*

Obtain samples of paper, taking care not to bend, roll, score or otherwise damage the area to be tested. From each test cut five test specimens free from scores or blemishes, 38.1 mm ± 03 mm wide by 70 mm ± 1 mm long, parallel to and at right angles to the machine direction.

13.3.3 *Procedure*

13.2.3.1 Condition the test specimens in accordance with IS 1060 (Part 1).

13.3.3.2 Place the instrument on a firm level surface. Set the loading disk at zero and place a chosen weight on the pendulum stud. If possible, choose a weight such that the resulting readings for the specimen to be tested are near the centre of the scale. Close the two jaws of the vice to meet on the centre line of the pendulum and adjust the legs of the instrument so that the engraved mark on the upper end of the pendulum coincide with zero on the scale of the fixed annular disk.

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

13.3.3.4 Place a test specimen in the vice with one end approximately level with its top edge and the other end between the rollers. With the two clamping screws of the vice, align the specimen with the centre line of the pendulum. Turn each of the screws for adjusting the rollers so that they just contact the specimen, then after taking up the backlash in one screw, back off one-quarter turn to give a clearance distance of 0.33 mm ± 0.03 mm greater than the thickness of the specimen.

NOTE — On instruments not equipped with adjustable, rollers, use the appropriate set of rollers for the thickness of the test specimen.

13.3.3.5 Switch on the motor to rotate the loading disk to the left and thus deflect the specimen until the engraved mark on the pendulum is aligned with the 15° mark on the loading disk. Stop the motor, record the scale reading, and immediately return the loading disk to zero. Take a similar reading by deflecting the specimen to the right. The stiffness of the specimen is taken as the average of the two readings. Test 5 specimens cut in each direction.

NOTES

1 On instruments not equipped with an electric brake, take the reading as the disk rotates over the end-point. If the instrument has a brake, check that it functions properly.

2 It is not necessary for the pendulum to balance at zero with the undeflected specimen in place. Curvature of the specimen would result in a difference between the two readings which are averaged to give the stiffness of the specimen.

13.3.4 *Report*

13.3.4.1 For each test unit and each direction report to three significant figures the average values in g/cm for five test specimens.

NOTE — A test with specimens cut with their length in the machine direction is reported as stiffness in that direction.

13.3.4.2 Report also the standard deviation of the individual results and the number of specimens tested in each direction.

13.3.5 The value may be expressed as stiffness factor as follows:

$$\text{Stiffness factor} = \frac{Averrage\ stiffness}{10\ T^3}$$

where

T = thickness in mm.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Paper Based Packaging Materials Sectional Committee, CHD 16

Organization	*Representative(s)*
Indian Institute of Packaging, New Delhi	PROF DR TANWEER ALAM **(*Chairperson*)**
B&A Packaging India Limited, Kolkata	SHRI AMAL KUMAR MOHANTY SHRI TAPAN KRUMAR CHAND (*Alternate* I) SHRI PANKAJ KUMAR MOHAPATRA (*Alternate* II)
Central Pulp and Paper Research Institute, Saharanpur	DR SANJAY TYAGI SHRI ALOK KUMAR GOEL (*Alternate*)
Century Pulp and Paper Mills, Nainital	SHRI SANJAY KUMAR YADAV SHRI HEM CHANDRA JOSHI (*Alternate*)
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Federation of Corrugated Box Manufacturers of India, Mumbai	SHRI K. P. SINGH SHRI ALOK KUMAR GUPTA (*Alternate*)
Federation of Paper Converters of India, New Delhi	SHRI MUKESH GUPTA SHRI ABHAY KUMAR SINGH (*Alternate*)
ITC Life Sciences and Technology Centre, Bengaluru	SHRI AJITH KUMAR DR KAMAL KUMAR TYAGI (*Alternate*)
ITC Limited, Paperboards and Specialty Papers Division, Bhadrachalam	SHRI P. N. SRIDHARR SHRI MOHAMMED GOUSE(*Alternate*)
Indian Agro and Recycled Paper Mills Association, New Delhi	DR BIPIN PRAKASH THAPLIYAl DR ANIL NAITHANI (*Alternate*)
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Indian Paper Manufacturers Association, New Delhi	SHRI BISWARANJAN DASH SHRI ROHIT PANDIT (*Alternate*)
J K Paper Limited, New Delhi	SHRI UMAKANT PATIL SHRI SAMEER MOHAPATRA (*Alternate*)

Organization	*Representative(s)*
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Package Design Research and Test Lab, Lucknow	SHRI L. M. GUPTA SHRI MAYANK GUPTA (*Alternate)*
Parksons Packaging Limited, Mumbai	SHRI SRIKANTH RAMAMURTHY SHRI RANJAN SINHA (*Alternate*)
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BIS Directorate General	SHRI AJAY KUMAR LAL, SCIENTIST 'F'/SENIOR DIRECTOR AND HEAD (CHEMICAL) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI VIRENDRA SINGH
SCIENTIST 'E'/DIRECTOR
(CHEMICAL), BIS

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