

INTERNATIONAL STANDARD

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Fourth edition
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Board — Determination of bursting strength

Carton — Détermination de la résistance à l'éclatement



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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

This fourth edition cancels and replaces the third edition (ISO 2759:2001), of which it constitutes a minor revision to include precision data.

Introduction

This International Standard is applicable to boards with bursting strengths between 350 kPa (or 250 kPa for the components of combined materials) and 5 500 kPa. All components of solid and corrugated fibreboard, irrespective of bursting strength, should be tested by this International Standard.

For materials with bursting strengths less than 1 400 kPa, an alternative method, based on similar principles, is specified in ISO 2758[1].

NOTE Due to differences in the specification of the apparatus, tests made on the same material using the procedures of ISO 2758 and this International Standard will not necessarily give the same results.

Board — Determination of bursting strength

1 Scope

This International Standard specifies a method for measuring the bursting strength of board submitted to increasing hydraulic pressure. It is applicable to all types of board (including corrugated and solid fibreboard) having bursting strengths within the range 350 kPa to 5 500 kPa. It is also applicable to papers or boards having bursting strengths as low as 250 kPa if the paper or board is to be used to prepare a material of higher bursting strength, such as corrugated board. In such cases, the measurements will not necessarily have the accuracy or precision stated for this method and it is necessary to include a note in the test report stating that the test gave results that were below the minimum value required by the method.

In the absence of any commercial agreement as to which method should be used for materials with bursting strengths between 350 kPa and 1 400 kPa, all materials with bursting strengths below 600 kPa, except components of solid and corrugated fibreboard, should be tested by ISO 2758 and the remainder by this International Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

ISO 536, *Paper and board — Determination of grammage*

3 Terms and definitions

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

3.1

bursting strength

maximum pressure developed by the hydraulic system in forcing an elastic diaphragm through a circular area of the board when the pressure is applied in the manner described in the method

Note 1 to entry: The indicated bursting pressure includes the pressure required to extend the diaphragm during the test.

3.2

burst index

bursting strength of the board divided by the grammage of the board determined in accordance with ISO 536

4 Principle

A test piece, placed over a circular elastic diaphragm, is rigidly clamped at the periphery but free to bulge with the diaphragm. Hydraulic fluid is pumped at a constant rate, bulging the diaphragm until the test piece ruptures. The bursting strength of the test piece is the maximum value of the applied hydraulic pressure.

5 Apparatus

The apparatus shall contain, as a minimum, the features described in [5.1](#) to [5.4](#).

5.1 Clamping system, for clamping the test piece firmly and uniformly between two annular, plane, parallel surfaces which shall be smooth (but not polished) and grooved as described in [Annex A](#), which also gives the dimensions of the clamping system.

One clamping plate shall be held in a swivel joint or similar device so as to ensure that the clamping pressure is distributed evenly.

Under the load used for testing, the circular openings in the two clamping plates shall be concentric to within 0,25 mm and the clamping surfaces shall be flat and parallel. The method of checking the clamps is given in [Annex B](#).

The clamping system shall be capable of applying a clamping pressure in the range 700 kPa to 1 200 kPa and shall be constructed in such a way that repeatable clamping pressures can be obtained in use (see [Annex C](#)).

In calculating the clamping pressure, the reduction in area due to the grooves shall be ignored.

Any clamping-pressure-indicating device fitted should preferably be scaled to indicate the actual clamping pressure, not the pressure in the clamping system itself. The clamping pressure may be calculated from clamping-force and clamp-area information.

5.2 Diaphragm, circular, of natural or synthetic rubber, free from filler or loading, clamped securely with its outer surface, when at rest, recessed about 5,5 mm relative to the outer plane of the diaphragm-mounting plate.

The material and construction of the diaphragm shall be such that the pressures required to bulge the diaphragm outside the outer plane of the diaphragm plate are as follows:

- bulge height: 10 mm \pm 0,2 mm, pressure range: 170 kPa to 220 kPa;
- bulge height: 18 mm \pm 0,2 mm, pressure range: 250 kPa to 350 kPa.

Diaphragms in use shall be regularly checked and changed if the bulge-height requirements are no longer met.

5.3 Hydraulic system, to apply an increasing hydraulic pressure to the inside of the diaphragm until the test piece bursts.

The pressure shall be generated by a motor-driven piston forcing a suitable liquid (e.g. pure glycerol, ethylene glycol containing corrosion inhibitor or low viscosity silicone oil) which is compatible with the diaphragm material against the inner surface of the diaphragm. The hydraulic system and the fluid used shall be free from air bubbles. The pumping rate shall be 170 ml/min \pm 15 ml/min.

5.4 Pressure-measuring system, to measure bursting strength.

It may employ any principle which produces a measurement and display accuracy equal to \pm 10 kPa or \pm 3 % of the measurement, whichever is the greater. The rate of response to the rising hydraulic pressure shall be such that the indicated maximum pressure is within \pm 3 % of the true peak pressure as determined by a calibration system of the type described in [Annex D](#).

6 Calibration

6.1 The apparatus should be fitted, or able to be fitted, with suitable test points to facilitate checking of the fluid pumping rate, calibration of the maximum pressure-measurement and display system and calibration of the clamping pressure-indicating device where fitted.

6.2 Calibration shall be carried out before initial use and at sufficiently frequent intervals to maintain the specified accuracy. Wherever possible, calibration of the pressure-sensing device should be carried out with it mounted in the same position it occupies on the apparatus and preferably on the apparatus itself. If a pressure sensor is accidentally subjected to pressure beyond its rated capacity, it shall be recalibrated before further use.

Aluminium foils of various thicknesses may be available for use as test pieces of known burst value. Such devices are a useful means of checking the overall function of an instrument but, since the behaviour of foil under stress is unlike that of paper, they should not be used as calibration standards.

7 Sampling and preparation of test pieces

The sampling procedure is not covered by this International Standard. Make sure that the test pieces taken for the determination are representative of the sample received. If the determination is to represent a lot of board, the sampling procedure shall be carried out in accordance with ISO 186. Where possible, test pieces shall not include areas containing watermarks, creases or visible damage.

Test pieces shall be conditioned in accordance with ISO 187.

The number of test pieces required depends on whether or not separate results are required for burst tests carried out with each surface in contact with the diaphragm.

8 Procedure

Tests shall be carried out in the standard atmosphere, defined in ISO 187, used for the conditioning of test pieces in accordance with [Clause 7](#).

If required, determine the grammage in accordance with ISO 536.

Prepare the apparatus for use in accordance with the manufacturer's instructions and the requirements of this International Standard. Electronic instruments may require a "warm-up" period.

Where alternative measuring pressure ranges are available, select the most suitable range, if necessary by carrying out a preliminary test using the highest available range.

Adjust the clamping system to give the lowest clamping pressure which prevents slippage of the test piece. A guide to clamping pressures which have proved satisfactory for materials of various bursting strengths is given in [Table 1](#).

Table 1

Bursting strength kPa	Clamping pressure kPa
up to 1 500	400
1 500 to 2 000	600
2 000 to 2 500	800
Over 2 500	1 000

Raise the clamp and insert the test piece in a position enabling the full clamping area to be used, then apply the full clamping pressure to the test piece.

If necessary, zero the hydraulic-pressure-indicating device according to the manufacturer's instructions. Apply hydraulic pressure until the test piece bursts. Retract the piston until the diaphragm is below the level of the diaphragm-clamping plate. Read the indicated bursting pressure to the nearest kilopascal. Release the clamp and prepare the instrument for the next test. Readings shall be rejected when visible slippage of the test piece (as shown by movement of the test piece area outside the clamps or by creasing of the test piece in the clamped area) has occurred. In cases of doubt, the use of a larger test piece will frequently establish whether slippage is occurring. Readings shall be rejected if the type of failure (for example, severance at the periphery of the test zone) indicates that the test piece was damaged by excessive clamping pressure or rotation of the clamps during clamping.

If separate results are not required for each surface of the board in contact with the diaphragm, 20 valid tests shall be carried out to obtain the result. If separate results are required for the two surfaces of board, a minimum of 10 valid tests shall be carried out on each side.

NOTE 1 The surface in contact with the diaphragm is considered to be the surface under test.

NOTE 2 The main sources of error are as follows:

- incorrect calibration of the pressure-measuring system;
- incorrect rate of increase in pressure (increased rates lead to an apparent increase in bursting strength);
- defective diaphragm, or diaphragm set too high or too low relative to the diaphragm-clamping plate;
- stiff or inelastic diaphragm, giving an apparent increase in bursting strength;
- inadequate or uneven clamping (which generally leads to an apparent increase in bursting strength);
- presence of air in the system (which generally leads to an apparent decrease in bursting strength).

9 Expression of results

Calculate the mean bursting strength, p , in kilopascals, to the nearest kilopascal.

Calculate the standard deviation of the results.

The burst index, x , expressed in kilopascals square metres per gram, may be calculated from the bursting strength by the formula

$$x = \frac{p}{g}$$

where

- p is the mean bursting strength, in kilopascals;
- g is the grammage of the board, in grams per square metre, determined in accordance with ISO 536.

Calculate the burst index to three significant figures.

10 Test report

The test report shall include the following information:

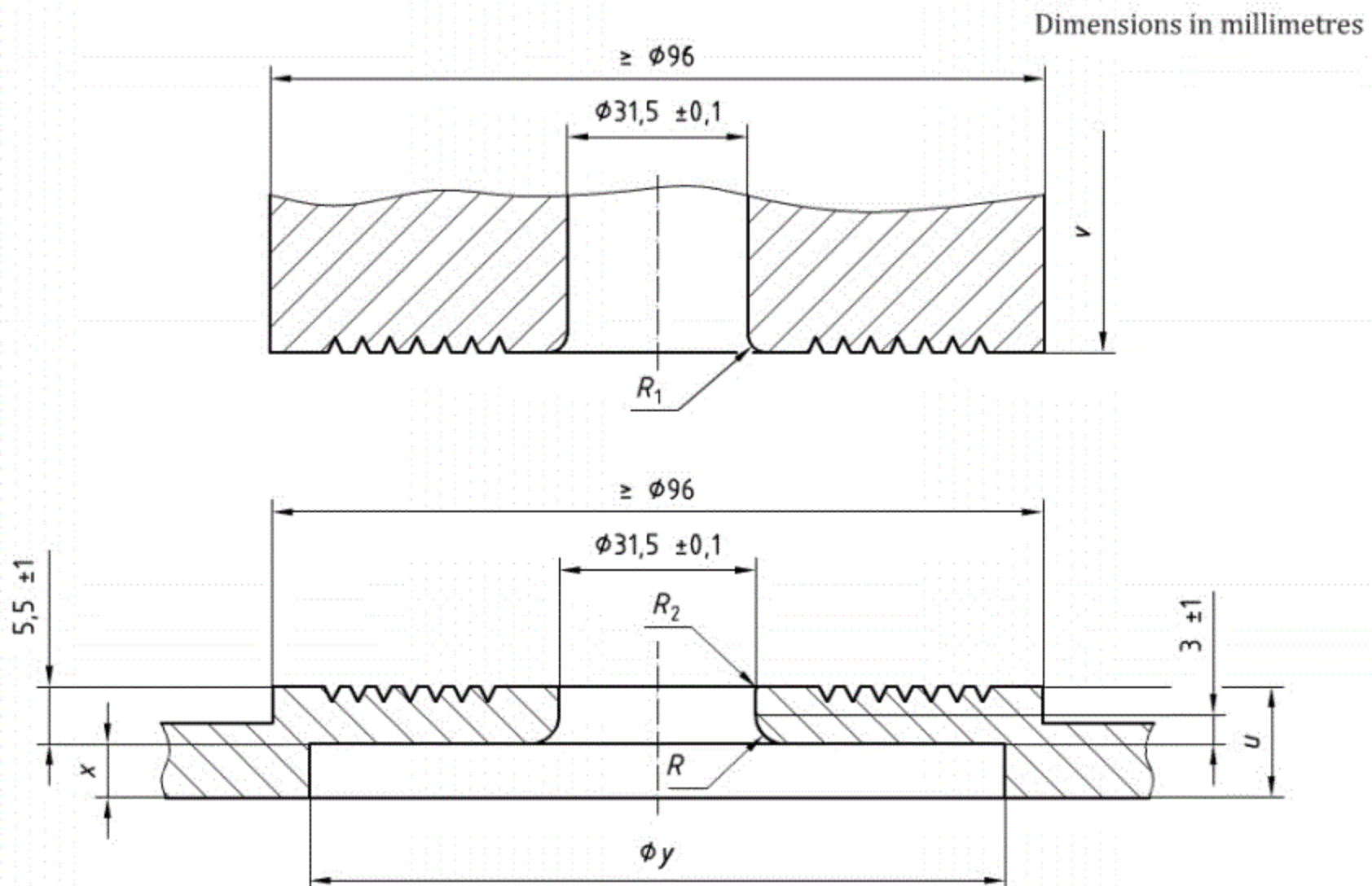
- a) a reference to this International Standard;
- b) the date and place of testing;

- c) all information necessary for complete identification of the sample;
- d) the make and type of instrument used;
- e) the standard conditioning atmosphere used;
- f) the mean value of the bursting strength, or both mean values if separate results have been obtained for each surface, to the nearest 1 kPa;
- g) if required, the burst index to three significant figures;
- h) the standard deviation of each mean bursting strength reported;
- i) any deviations from the method specified.

Annex A (normative)

Dimensions of the clamping system

The dimensions of the clamps are shown in [Figure A.1](#).



Key

R , R_1 , R_2 , u , v , x and y are specified in the text of this annex.

Figure A.1 — Clamps

The dimensions of an alternative lower clamp are shown in [Figure A.2](#). This clamp may sometimes be found on instruments of North American manufacture.

Dimensions u and v (see [Figure A.1](#)) are not critical but shall be large enough to ensure that the clamps do not distort during use. For the moving clamp, a minimum thickness of 9,5 mm has been found satisfactory in use.

Dimensions x and y may vary according to the manufacturer of the burst tester and the design of the diaphragm used but are such that the diaphragm is securely clamped.

Radius R is set by the limits imposed by the dimensions $5,5 \text{ mm} \pm 1,0 \text{ mm}$ and $3 \text{ mm} \pm 1 \text{ mm}$. The arc shall be tangential to the vertical face of the circular opening and to the horizontal inner surface of the diaphragm clamp. The radius shall be about 3 mm.

To reduce the danger of damage to the test piece or the diaphragm, R_1 and R_2 shall be very slightly rounded but not sufficiently to affect the bore of the moving clamping plate. (Radii of curvature of about 0,6 mm for R_1 and 0,4 mm for R_2 are recommended.)

To minimize slippage, the clamp surfaces which come into contact with the board during a test shall have spiral or concentric tool marks on the surface.

The following have been found to be satisfactory:

- a) a continuous spiral 60° V-groove not less than 0,25 mm deep, with a pitch of 0,9 mm \pm 0,1 mm, the groove starting at 3,2 mm \pm 0,1 mm from the edge of the circular opening;
- b) a series of concentric 60° V-grooves not less than 0,25 mm deep and 0,9 mm \pm 0,1 mm apart, the centre of the innermost groove being 3,2 mm \pm 0,1 mm from the edge of the circular opening.

The space above the circular opening in the moving clamp shall be of sufficient size to allow free bulging of the test piece and, if enclosed as a design feature, shall be connected to the atmosphere by a circular opening of sufficient size to allow air trapped above the test piece to escape. A circular opening of about 4 mm diameter has been found to be suitable

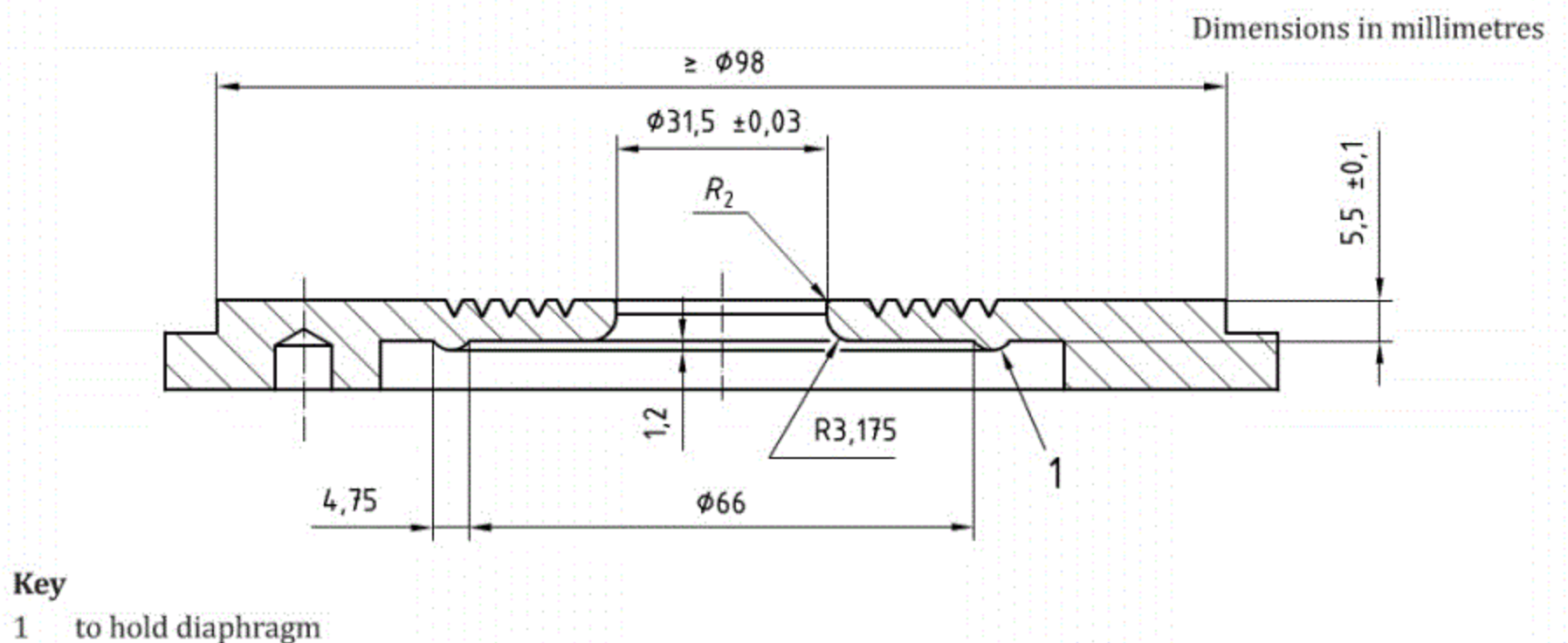


Figure A.2 — Alternative lower clamp

Annex B (normative)

Testing the clamps

Place a piece of pencil carbon paper, together with a piece of thin white paper, between the clamping plates and apply the normal clamping pressure. If the clamping plates are satisfactory, the impression transferred from the carbon paper to the white paper will be clear, uniform and well defined over the whole clamping area. If the moving clamping plate can be rotated, rotate it through 90° and obtain a second impression. The concentricity of the clamping plates may be checked either by checking that the clamping plates line up correctly on a plate fitted with discs on each side corresponding in diameter with the dimensions of the circular opening, or by taking a clamping impression using two sheets of carbon paper with a sheet of thin, white paper between them and checking that the clamping impressions are symmetrical and correspond to within 0,25 mm.

Annex C (normative)

Clamping pressure

Some testers are fitted with a hydraulic or pneumatic clamping device, incorporating a pressure gauge, and can be readily adjusted to give any required clamping pressure. In such cases, it must be stressed that the pressure in the pneumatic or hydraulic system is not necessarily identical with the pressure between the clamps. The areas of the piston and the clamp faces must be taken into account.

In the case of testers fitted with mechanical clamping devices, such as screws or levers, the actual clamping pressure at various settings should be determined by use of a load cell or other suitable device.

Annex D (normative)

Calibration of pressure-measuring system

D.1 Static calibration

The pressure-measuring system may be calibrated statically by means of a deadweight tester of the piston type or by means of a column of mercury. If the pressure-sensing device is sensitive to orientation, calibration should be carried out with the sensor mounted in its normal position in the burst tester. The maximum bursting-pressure-indication system should be calibrated dynamically.

Other methods of static calibration can be used.

D.2 Dynamic calibration

Dynamic calibration of the complete instrument may be carried out by connecting in parallel an independent maximum-pressure-measuring system. The system shall have a frequency response and accuracy sufficient to measure the maximum pressure during the burst test to better than $\pm 1,5\%$.

By testing samples covering the working range of the instrument, the error in the indicated maximum bursting pressure at various bursting-pressure levels may be determined.

If the error at any point is greater than the requirements of [5.4](#), the source of the error shall be investigated.

Annex E (informative)

Precision

E.1 General

In 2012, 13 laboratories tested 4 samples of board and 12 laboratories tested 2 samples of corrugated board according to ISO 2759. The data have been obtained from CEPI-CTS, the Comparative Testing Service of the Confederation of European Paper Industries.

The data for bursting strength board are presented in [Table E.1](#) and [Table E.2](#). The data for bursting strength corrugated board are presented in [Table E.3](#) and [Table E.4](#).

The calculations were made according to ISO/TR 24498[3] and TAPPI T 1200[2].

The repeatability standard deviation reported 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. 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.:

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

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.

E.2 Bursting strength — board

Table E.1 — Estimation of the repeatability (board)

Sample	Number of laboratories	Mean bursting strength kPa	Repeatability standard deviation s_r kPa	Coefficient of variation $C_{V,r}$ %	Repeatability limit r kPa
Sample 1	12	349	16,0	4,6	44,4
Sample 2	13	662	19,8	3,0	54,9
Sample 3	13	816	23,6	2,9	65,4
Sample 4	13	1 315	89,0	6,8	246,7

Table E.2 — Estimation of the reproducibility (board)

Sample	Number of laboratories	Mean edge bursting strength kPa	Reproducibility standard deviation s_R kPa	Coefficient of variation $C_{V,R}$ %	Reproducibility limit R kPa
Sample 1	12	349	37,3	10,7	103,4
Sample 2	13	662	38,5	5,8	106,7
Sample 3	13	816	53,6	6,6	148,5
Sample 4	13	1 315	122,4	9,3	339,2

E.3 Bursting strength — corrugated board

Table E.3 — Estimation of the repeatability (corrugated board)

Sample	Number of laboratories	Mean bursting strength kPa	Repeatability standard deviation s_r kPa	Coefficient of variation $C_{V,r}$ %	Repeatability limit r kPa
Sample 1	12	971	45,0	4,6	124,9
Sample 2	10	2 578	129,3	5,0	358,5

Table E.4 — Estimation of the reproducibility (corrugated board)

Sample	Number of laboratories	Mean bursting strength kPa	Reproducibility standard deviation s_R kPa	Coefficient of variation $C_{V,R}$ %	Reproducibility limit R kPa
Sample 1	12	971	104,8	10,8	290,5
Sample 2	10	2 578	215,7	8,4	597,9

Bibliography

- [1] ISO 2758:2001, *Paper — Determination of bursting strength*
- [2] ISO 5725-1, *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*
- [4] Appita Standard AS/NZS 1301-403s:1997¹⁾
- [5] TAPPI T 807, *Bursting strength of linerboard, Test Method*
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1) Methods of dynamic calibration for pressure gauges are described in this publication.

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