INTERNATIONAL STANDARD ISO 2758

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Paper — Determination of bursting strength

Papier — Détermination de la résistance à l'éclatement

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FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2758 was drawn up by Technical Committee ISO/TC 6, *Paper, board and pulps,* and circulated to the Member Bodies in July 1972.

It has been approved by the Member Bodies of the following countries :

Australia	Iran	Spain
Austria	Ireland	Sweden
Czechoslovakia	Israel	Switzerland
Egypt, Arab Rep. of	Netherlands	Thailand
Finland	New Zealand	Turkey
France	Norway	United Kingdom
Germany	Poland	U.S.A.
Hungary	Romania	
India	South Africa, Rep. of	

The Member Body of the following country expressed disapproval of the document on technical grounds :

Belgium

Printed in Switzerland

Paper — Determination of bursting strength

0 INTRODUCTION

This International Standard is applicable to papers with bursting strengths of up to 1 100 kPa.

For materials with bursting strengths greater than 350 kPa (or 250 kPa for the components of combined materials) an alternative method based on similar principles is given in ISO 2759.

Many instruments in use for determining this property are at present scaled in kilograms-force per square centimetre. For the purpose of this International Standard 1 kgf/cm^2 = 98,1 kPa.

1 SCOPE

This International Standard specifies a method for measuring the bursting strength of paper submitted to increasing hydraulic pressure.

2 FIELD OF APPLICATION

This International Standard is applicable to paper with bursting strengths within the range 70 to 1 100 kPa. It should not however generally be used for the components (such as fluting medium or linerboard) of a combined board, for which the method given in ISO 2759 is more suitable. Paper of bursting strength less than 70 kPa may also be tested by bursting a number of sheets simultaneously.

3 REFERENCES

ISO/R 186, *Method of sampling paper for testing.*

ISO/R 187, *Method for the conditioning of paper and board test samples.*[1]

ISO/R 536, *Determination of paper substance.*[1]

ISO 2759, *Board — Determination of bursting strength.*

4 DEFINITIONS

For the purpose of this International Standard, the following definitions apply :

4.1 bursting strength : The maximum uniformly distributed pressure, applied at right angles to its surface, that a test piece of paper will stand under the conditions of this test.

4.2 burst index : The bursting strength of the paper divided by the grammage of the conditioned paper determined by the standard method of test.

5 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.

6 APPARATUS

The apparatus shall be installed on a horizontal surface and be free from externally induced vibrations.

All air shall be removed from the hydraulic system by bleeding. The whole apparatus shall be checked for expansion and for leaks using the methods given in annexe E.

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

The upper clamping plate shall be held in a swivel joint or otherwise so as to ensure that the clamping pressure is distributed evenly.

1) At present under revision.

During tests, the apertures in the two clamping plates shall be concentric to within 0,25 mm and the clamping surfaces shall be flat and parallel. Methods of checking the clamps are given in annex B.

The clamping force shall be sufficient to prevent slippage during a test (see clause 9) but not so great as to damage the test piece in such a way that rupture occurs around the periphery of the test area. Normally the clamping force shall be not less than 2 700 N (see annex C). For some papers, clamps of larger area than the minimum specified may be required to prevent slippage.

A maximum clamping force, and also a minimum, differing from that stated above may be agreed between the parties concerned, in which case the agreed limit or limits of clamping force shall be stated in the test report.

6.2 Diaphragm, circular, of elastic material, clamped securely with its upper surface about 3,5 mm below the top plane of the lower clamping plate. The material and construction of the diaphragm shall be such that the pressure required to bulge the diaphragm 9 mm above the top face of the lower clamping plate is 30 ± 10 kPa.

A new diaphragm will frequently require a higher pressure for a given bulge height than one which has been used for a while. Diaphragms shall be checked at frequent intervals and re-fitted or changed if the bulge height requirements are not met. Care shall be taken during the fitting of a diaphragm to eliminate all air trapped under the diaphragm.

6.3 Hydraulic system to apply a controlled hydraulic pressure to the underside of the diaphragm until the test piece bursts. The pressure shall be generated by a piston forcing a suitable liquid (chemically pure glycerol, ethylene glycol containing a corrosion inhibitor, or a low viscosity silicone oil) against the under surface of the diaphragm. The hydraulic system and liquid used shall be free from air bubbles. The pumping rate shall be 95 ± 5 ml/min (see annex E).

A motor-operated piston is recommended; if a hand-operated instrument is used, this fact shall be clearly stated in the report.

6.4 Pressure gauge, maximum reading Bourdon type, of appropriate capacity. It should preferably be used within the range 25 to 75 % and in no case outside the range 15 to 85 % of the capacity of the scale.[1)] The scale shall have a minimum diameter of 95 mm and graduations extending over a minimum arc of 270°. At any point within the working range it shall be accurate to within ± 0,5 % of the maximum capacity of the scale. The scale shall be sub-divided into at least 70 divisions.

The expansibility of the gauge shall be constant to within ± 20 % over its full working range and be such that the hydraulic fluid required to give a full scale reading does not exceed 0,4 ml (see annex E). The gauge shall be fitted with a scale adjustment device for fine setting.

The maximum reading pointer shall not introduce errors into the scale readings during use. This can only be confirmed by dynamic calibration of the gauge, but gauges with pointers having a frictional couple of about 0,3 mN·m and a moment of inertia of between 1 and 10 g·cm^2 have been found to be satisfactory (see annex D).

The gauge shall be provided with a bleed hole or other device to facilitate the complete filling of the gauge with hydraulic fluid.

The total measuring range of the instrument may be divided by the use of two gauges. The gauges shall be independent of each other in use; by checking the expansibility of the system on each range with the selector valve in the appropriate position, the suitability of the selector valve will be confirmed (see annex E).

7 CALIBRATION

Each gauge shall be calibrated before initial use and afterwards at sufficiently frequent intervals to maintain the specified accuracy. A deadweight tester may be used (see annex D). Calibration shall be carried out with the gauge mounted in the same position as it occupies on the instrument and preferably when mounted on the instrument. If the gauge is accidentally used beyond its capacity it shall be recalibrated before being used again.

Routine calibration checks on the instrument may be carried out using standardized foil test pieces for pressures up to about 800 kPa.

NOTE — Suppliers of foil test pieces are listed in annex G.

8 SAMPLING AND PREPARATION OF TEST PIECES

The paper to be tested shall be sampled in accordance with ISO/R 186. Test pieces shall be larger in area than the clamp of the burst tester and no area covered by the clamp in one test shall be included in subsequent test areas.

Test pieces shall not include areas containing watermarks, creases or visible damage.

Test pieces shall be conditioned in accordance with ISO/R 187.

1) Unless the capacity of the gauge is known to exceed the graduated scale reading by 20 %, in which case the upper limits of scale reading may be increased to 90 % and 100 % respectively.

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.

NOTE — When laboratory sheets are being tested and when only narrow samples are available for testing, it may not be possible to avoid the clamped area overlapping the edges of the test piece or an adjacent clamped area. In such instances the overlap shall be carefully minimized and the test piece inspected after use to ensure that the overlap has not caused the clamped paper to slip. If clamping is not in accordance with the stated procedure this fact shall be stated in the test report.

9 PROCEDURE

Tests shall be carried out in a standard atmosphere as defined in ISO/R 187, used for the conditioning of test pieces in accordance with clause 8.

Where alternative gauges are available, select the most suitable gauge, if necessary by carrying out a preliminary test using the gauge with the greatest range, and isolate the other gauges.

Raise the clamp and insert the test piece in a position enabling the full clamping area to be used (see note to clause 8); then firmly apply the clamp to the test piece at the clamping force specified in 6.1.

Apply hydraulic pressure at the correct rate until the test piece bursts. Retract the piston until the diaphragm is below the level of the lower clamping plate. Read the pressure indicated on the gauge to three significant figures. Then release the clamp and return the maximum reading pointer to its starting position 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 occured. In cases of doubt, the use of a larger test piece will frequently establish whether slippage is occurring. Readings shall also 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 by rotation of the clamps during clamping.

If the reading is less than 70 kPa burst the minimum number of sheets simultaneously to give a reading above 70 kPa. These sheets shall be arranged top side to wire side with machine directions parallel.

NOTE — Care shall be taken when returning the pointer to the starting position. On some instruments, too rapid a return may damage the pointer.

If separate results are required with each surface of the paper in contact with the diaphragm, twenty tests shall be carried out for each result. If separate results are not required for the two surfaces of the material, ten tests shall be made with the wire side uppermost and ten tests with the top side uppermost.

NOTE — The surface in contact with the diaphragm is considered as the surface under test.

10 CALCULATION AND EXPRESSION OF RESULTS

For tests in which the test piece is made up from a number of sheets, the bursting strength is obtained by dividing the gauge reading by the number of sheets tested simultaneously.

The burst index, X, in kilonewtons per gram, may be calculated from the bursting strength as follows :

$$X = \frac{P}{W}$$

where

P is the mean bursting strength in kilopascals;

W is the grammage of the specimen, in grams per square metre, determined in accordance with ISO/R 536.

11 PRECISION OF RESULTS

The precision of results depends to a great extent on the variability of the material tested and the accuracy on a large number of factors, the most important possibly being the efficiency of clamping.

It is difficult under practical circumstances to separate these but some typical results will illustrate the variations likely to be encountered.

Within laboratory (15 papers) :

Coefficient of variation of individual results 3,6 to 13,2 %.

95 % confidence limits of mean result ± 1,7 to 6,1 %.

Between laboratories (randomized test pieces) :

Coefficient of variation of mean results 2,1 to 9,6 %.

Thus it can be seen that, generally, depending on the value of the bursting strength, differences in the mean results for two papers of less than about 5 % on a single instrument or about 10 % on instruments in different laboratories cannot be taken as proof of a real difference in bursting strength.

12 SOURCES OF ERROR

The main sources of error are :

— faulty calibration of the pressure gauge (see annex D);

– incorrect rate of rise of pressure (increased rates lead to an apparent increase in bursting strength) (see annex E);

– incorrect diaphragm (see 6.2);

– inadequate or uneven clamping (which generally leads to an apparent increase in bursting strength) (see annexes B and C);

– air in the system (which generally leads to an apparent decrease in bursting strength) (see annex E).

13 TEST REPORT

The test report shall include the following particulars :

a) a reference to this International Standard;

b) the date and place of testing, the make of instrument and the model number;

c) whether the instrument used was hand-operated;

d) the standard conditioning atmosphere used;

e) the mean value of the bursting strength in kilopascals to three significant figures (from each surface of the paper where required);

f) if required, the burst index to three significant figures;

g) the 95 % confidence limits of the mean bursting strength;

h) in the case of multiple sheet testing, the number of sheets used;

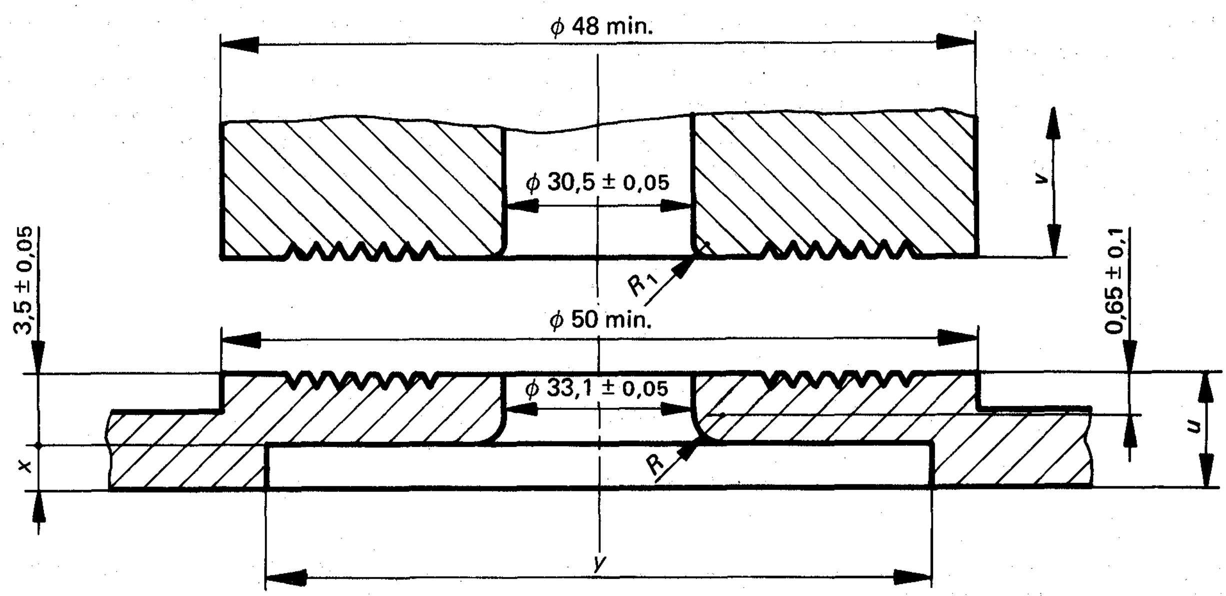
i) any deviation (including force limits) from the recommended clamping conditions;

j) any deviation (not mentioned above) from the recommended method.

ANNEX A

DIMENSIONS OF THE CLAMPING SYSTEM

Dimensions in millimetres



R, R_1, *u*, *v*, *x* and *y* are specified in the text.

FIGURE – **The clamps**

Dimensions *u* and *v* are not critical but shall be large enough to ensure that the clamps do not distort during use. For the top clamp, a minimum thickness of 6,35 mm has been found satisfactory in use.

Dimensions *x* and *y* depend on the burst tester and on the diaphragm used but shall be such that the diaphragm is securely clamped.

Radius *R* is set by the limits imposed by the dimensions 3,5 ± 0,05 and 0,65 ± 0,1 mm. The arc shall be tangential to the vertical face of the orifice and to the horizontal bottom surface of the lower clamp. The radius shall be about 3 mm.

To reduce the danger of damage to the test piece or diaphragm, R_1 shall be very slightly rounded off but not sufficiently to affect the bore of the upper clamping plate. A radius of curvature of about 0,2 mm is recommended.

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

The following have been found very satisfactory :

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

The space above the orifice in the upper clamp shall be of sufficient size to allow free bulging of the test piece and shall be connected to the atmosphere by an orifice of sufficient size to allow air trapped above the test piece to escape. An orifice of diameter about 4 mm has been found adequate.

ANNEX B

TESTING THE CLAMPING

Place a piece of pencil carbon paper, together with a piece of thin white paper, between the clamps and apply the normal clamping force. If the clamps 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 upper clamp can be rotated, the clamping impression shall be repeated at right angles to the original impression.

The concentricity of the clamps may be checked either by checking that the clamps line up correctly on a plate fitted with discs on each side corresponding in diameter with the orifice dimensions, 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 in register.

ANNEX C

CLAMPING FORCE

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 force. In such cases, it must be stressed that the pressure in the hydraulic or pneumatic system is not necessarily identical with the pressure between the clamps. The areas of the piston and of the clamp faces must be taken into account.

Testers fitted with a hand-operated clamping wheel can be suitably modified by attaching to the wheel a square socket adapter which will accept a standard adjustable torque wrench. Testers so modified shall be individually calibrated with a load cell to determine the torque wrench settings corresponding to the stipulated clamping force. It is important, however, that the top clamp screw be maintained undamaged, clean and lightly oiled to minimize friction.

Lever-operated clamps are normally spring-loaded. If the compression spring is calibrated, the compression of the spring will give an indication of the clamping force. The calculated values shall be confirmed using a load cell or other suitable method.

ANNEX D

GAUGE CALIBRATION

The gauge may be calibrated statically by means of a deadweight tester of the piston type or by means of a column of mercury. Such calibration shall be carried out with the gauge in the same position as in the bursting tester.

Pressure gauges are subject to dynamic in addition to static calibration errors; dynamic calibration is therefore advisable. For references to methods see annex F.

D.1 POINTER INERTIA AND FRICTION

The moment of inertia of the maximum reading pointer may be calculated from the geometry and mass of the pointer.

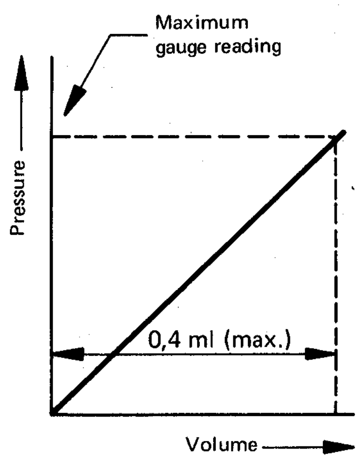
The pointer friction can be determined by resting a small loop of wire on the pointer when placed horizontally with the gauge mounted vertically. A torque of between 0,2 and 0,4 mN·m calculated from the mass of the wire loop and its distance from the pointer shaft, shall be required to cause the pointer to move slowly and smoothly when the gauge is rotated or lightly tapped.

D.2 GAUGE EXPANSIBILITY

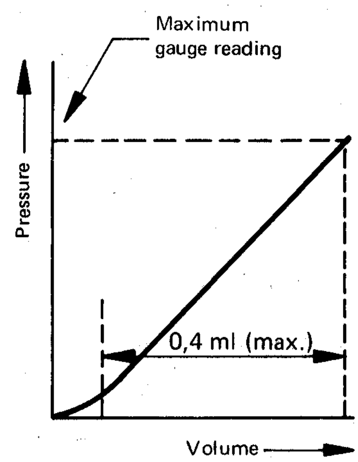
The expansibility of the gauge may be determined by a calibrated plunger or dilatometer. With the system free of air the plunger shall be moved forward by known amounts and the pressure developed in the gauge noted.

ANNEX E

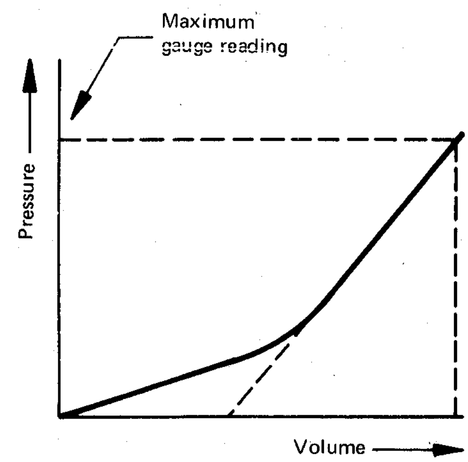
CHECKING OF HYDRAULIC SYSTEM



Expansion curve for gauge alone



Expansion curve for air-free burst tester and gauge



Expansion curve for burst tester and gauge with some air in the system

This shall be carried out by mounting a rigid plate in the position normally occupied by the diaphragm and by advancing the piston by known amounts. The pressure in the system will rise and if there is no trapped air a graph of volume change against pressure will give a value for the expansibility of the hydraulic system that is only slightly greater than that of the gauge alone.

A very high initial expansibility indicates the presence of air in the hydraulic system.

A routine test for air in the system and for leaks may be carried out by clamping a metal plate with fine scores on the under surface or with fine (1 mm diameter) perforations, between the burst tester clamps. After the volume of the void below the clamped plate has been filled by hydraulic fluid the expansibility of the system shall be substantially that of the gauge alone.

With this rigid plate in position and the hydraulic system initially at the maximum gauge pressure, the pressure shall not fall by more than 10 % in 1 min.

Check the pumping rate of the apparatus as follows :

Fill the space between the diaphragm and the top of the lower clamp with water or ethanol. Place a thin rubber sheet and a steel plate on top of the clamp and clamp tightly. Connect a burette to the pressure chamber of the tester by means of rubber tubing. Remove all air from the hydraulic system. With the burette vertical add hydraulic liquid to bring the level up to one of the points of the burette scale. With the piston in the forward moving position, turn the motor shaft by hand and measure the volume of the liquid pumped out as a function of the number of revolutions. From this value and the speed of the motor calculate the pumping rate which shall be 95 ± 5 ml/min.

ANNEX F

BIBLIOGRAPHY

Methods of dynamic calibration are described in the following publications

1) BRAUNS, O., DANIELSSON, E., JORDANSSON, L., *Svensk Paperstidning* **23** 867 (1954).

2) TUCK, N.G.M., MASON, S.G., FAICHNEY, L.M., *Pulp and Paper Mag. Canada* **54** 5 102 (1953).

3) APPITA P403 61.

ANNEX G

STANDARDIZED FOILS

Standardized foils for routine calibration of burst testers may be obtained from :

Pulp and Paper Research Institute of Canada
570 St. John's Road
POINTE CLAIRE 720
Quebec
Canada

The Research Association for the Paper and Board, Printing and Packaging Industries (PIRA)
Randalls Road
LEATHERHEAD
Surrey
England