TC 6

International Standard 5627

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Paper and board — Determination of smoothness (Bekk method)

Papier et carton — Détermination du lissé (Méthode Bekk)

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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 5627 was developed by Technical Committee ISO/TC 6, *Paper, board and pulps*, and was circulated to the member bodies in February 1983.

It has been approved by the member bodies of the following countries :

Belgium	Iran	Sweden
Bulgaria	Italy	Switzerland
China	Korea, Rep. of	Tanzania
Czechoslovakia	Mexico	Thailand
Egypt, Arab Rep. of	Netherlands	Turkey
Finland	Norway	United Kingdom
France	Poland	USA
Germany, F. R.	Romania	Venezuela
Hungary	South Africa, Rep. of	
India	Spain	

No member body expressed disapproval of the document.

Paper and board — Determination of smoothness (Bekk method)

0 Introduction

In the present state of knowledge it is not possible to recommend a single method for measuring the smoothness or roughness of a paper or board and there is no exact correlation among the various methods used for determining these properties. Instruments of the air-flow type are designed to obtain a numerical value indicative of the smoothness or roughness of the paper or board; it is necessary to refer to the results of these tests in terms of the specific type of instrument used, as Bendtsen roughness, Sheffield roughness, Bekk smoothness, etc. In general the Bekk method is suitable for more smooth paper and the Bendtsen method for less smooth paper.

Bekk smoothness is dependent on the shape, total volume and distribution of the hollow spaces between the surface of the test piece and a theoretically ideal plane under the specified conditions of contact. The greater the Bekk smoothness number the smoother the sample.

The air permeability of the sample being tested can also affect the results.

1 Scope and field of application

This International Standard specifies a method of measuring the smoothness of paper and board by the Bekk method.

The smoothness of a wide range of papers and boards can be measured by this method but it should not be used for testing materials greater than 0,5 mm thick or very permeable papers or boards since the amount of air passing through the test piece can falsify the result.

2 References

ISO 48, *Vulcanized rubbers — Determination of hardness (Hardness between 30 and 85 IRHD).*

ISO 186, *Paper and board — Sampling for testing.*

ISO 187, *Paper and board — Conditioning of samples.*

ISO 4662, *Rubber — Determination of rebound resilience of vulcanizates.*

3 Definition

For the purpose of this International Standard the following definition applies :

Bekk smoothness : The time in seconds which, under a defined pressure differential, is required to draw a definite quantity of air at atmospheric pressure between the surface of the test piece and a ring-shaped plane surface, under specified conditions of contact (see figure 1).

4 Principle

Subjection of a test piece of paper or board placed on a glass plate to a specified pressure and creation of a partial vacuum to draw atmospheric air across the contact surface. Measurement of the time for a specified change in vacuum.

5 Apparatus and equipment

5.1 Glass plate, that conforms to the design shown in figure 2. The test surface shall be circular, plane and perfectly polished and have a contact area of approximately 10 cm^2. The central hole in the glass plate shall be capable of being connected with a vacuum container and also of being disconnected.

A supporting metal plug should be placed loosely in the hole with its upper surface in plane with the upper side of the glass plate to prevent the test piece from being pressed into the hole. If fitted, this plug shall have a central hole of diameter 1,5 to 2,0 mm. Its base shall have four radial channels through which the air can pass without obstruction.

NOTE — Some instruments have a glass plate without a plug. For most papers this does not significantly affect the results obtained, but the use of a plug is desirable.

The test surface shall be kept scrupulously clean and shall not be touched by hand. Before each measurement any fibres and the like that may have adhered to the plate shall be removed. When not in use the plate shall be protected by a cover. Scratches or cracks render it unusable.

5.2 Device to clamp the test piece against the glass plate, with a pressure of 100 ± 2 kPa.* In the known instruments this device is a weighted lever.

5.3 Pressure plate, having a circular, even surface of not less than 45 mm diameter and which shall be connected to the device that presses the pressure plate against the glass plate at 100 kPa.

5.4 Rubber pad, placed between the pressure plate and the test piece. When examined by incident light under a magnifying glass the surface of the rubber pad shall be free from marks, scratches and tears and shall have the following dimensions :

a) thickness : 4 ± 0,2 mm (measured with a ratchet screw micrometer having an anvil diameter of approximately 8 mm); the maximum thickness variation of one pad shall be ± 0,05 mm;

b) surface : circular with a diameter of not less than 45 mm, or rectangular with sides not less than 50 mm in length.

Furthermore, the rubber pad shall have the following mechanical properties :

a) hardness : 40 ± 5 IRHD (according to ISO 48);

b) rebound resilience : at least 62 % (according to ISO 4662).

5.5 Vacuum containers, that shall be capable of being evacuated to a vacuum of 53,35 kPa** and shall be capable of being hermetically sealed.

5.5.1 Large vacuum container, having a volume, including the connecting tube up to the surface of the glass plate, of 380 ± 1 ml.

5.5.2 Small vacuum container, having a volume, including the connecting tube up to the surface of the glass plate, of 38 ± 1 ml. This container is not fitted to all instruments in which case means are provided to reduce the volume of the large vacuum container to 190 ml or 95 ml.

5.6 Manometer, capable of indicating the vacuum corresponding to 50,66 kPa**, 48,00 kPa and 29,33 kPa to an accuracy of ± 0,07 kPa. A drop in the vacuum from 50,66 to 48,00 kPa means that 10 ml of the ambient air has entered the large container or 1 ml has entered the small container. A drop in vacuum from 50,66 to 29,33 kPa means that 80 ml of the ambient air has entered the large container.

5.7 Timing device, capable of being read to the nearest 1 s.

6 Sampling

Select specimens in accordance with ISO 186 making sure that there are no folds, creases, visible cracks or other defects in the area to be tested. The test pieces shall not include any part of the sample that is less than 15 mm from the edge of the sheet or reel. If watermarks are present, these areas should be avoided if possible.

Take at least ten test pieces, for each side to be tested, each larger in area than the pressure plate. To ensure careful handling of the test pieces, the size should not exceed A4 size. Identify the sides of the test pieces.

7 Conditioning

Condition the test pieces in accordance with ISO 187. Carry out tests in the same conditioning atmosphere.

8 Procedure

8.1 Check the parts of the apparatus when necessary, as detailed in the annex, before proceeding to measure the smoothness of the test pieces.

8.2 Place the apparatus on a level surface free from vibration. Remove the protective cover from the glass plate (5.1).

The smoothness of the side to be tested shall be measured for ten test pieces. A separate test area shall be used for each measurement. That is to say, the smoothness of both sides may not be measured on the same test piece. Place the test pieces with the side to be tested on the glass plate in such a manner that the glass plate is fully covered. Place the rubber pad (5.4) and the pressure plate (5.3) on the test piece, apply a pressure of 100 kPa and produce a vacuum of more than 50,66 kPa in the large vacuum container (5.5.1).

Connect the vacuum container to the hole in the glass plate 60 ± 5 s after application of the load.

Measure the time in seconds for the vacuum in the large vacuum container to drop from 50,66 to 48,00 kPa. If the time exceeds 300 s then connect the smaller vacuum container (5.5.2) and repeat the test with a fresh test piece. If the time is less than 15 s repeat the test with a fresh test piece and a vacuum drop from 50,66 to 29,33 kPa.

If required, measure the smoothness of the other side of the samples with ten further test pieces.

9 Expression of results

9.1 Calculation

From the individual readings in seconds, calculate the arithmetic mean separately for each side.

* 1 kPa = 10^3 N/m^2 = 1 kN/m^2

** 1 kPa = 10^3 N/m^2 = 7,5 mmHg

If the measurements are made using the large vacuum container then the mean values are the Bekk smoothness. If the measurements are made with the smaller container, multiply the arithmetic means by ten in order to obtain the Bekk smoothness.

NOTE — When a vacuum drop of 50,66 to 29,33 kPa has been used, the time shall be divided by ten to obtain the Bekk smoothness.

In addition, calculate the standard deviation or coefficient of variation of the Bekk smoothness for both sides.

9.2 Precision

Based on the results for numerous papers and laboratories obtained from the TAPPI Collaborative Reference Program for paper between 1971 and 1976, the precision of the test piece is as given in the following table.

Table

Range of smoothness values of paper tested s	Repeatability, %		Reproducibility, %	
	range	average	range	average
4 to 1 400	5 to 21	11	21 to 56	37

The repeatability of the test is largely dependent on the variability of the sample.

10 Test report

The test report shall include the following particulars :

a) reference to this International Standard;

b) all the information necessary for complete identification of the sample;

c) the standard atmosphere used for conditioning and testing;

d) the results, to the nearest second, expressed as one mean value for each side tested, for example smoothness (Bekk) 152 s. If the smaller vacuum container has been used then this should be noted;

e) the standard deviation or coefficient of variation and, if required, the 95 % confidence limits of the mean smoothness;

f) whether tests were done on watermarked portions of the test pieces;

g) any unusual features observed in the course of the test;

h) any operations not specified in this International Standard, or in the International Standards to which reference is made or regarded as optional, which might have affected the results.

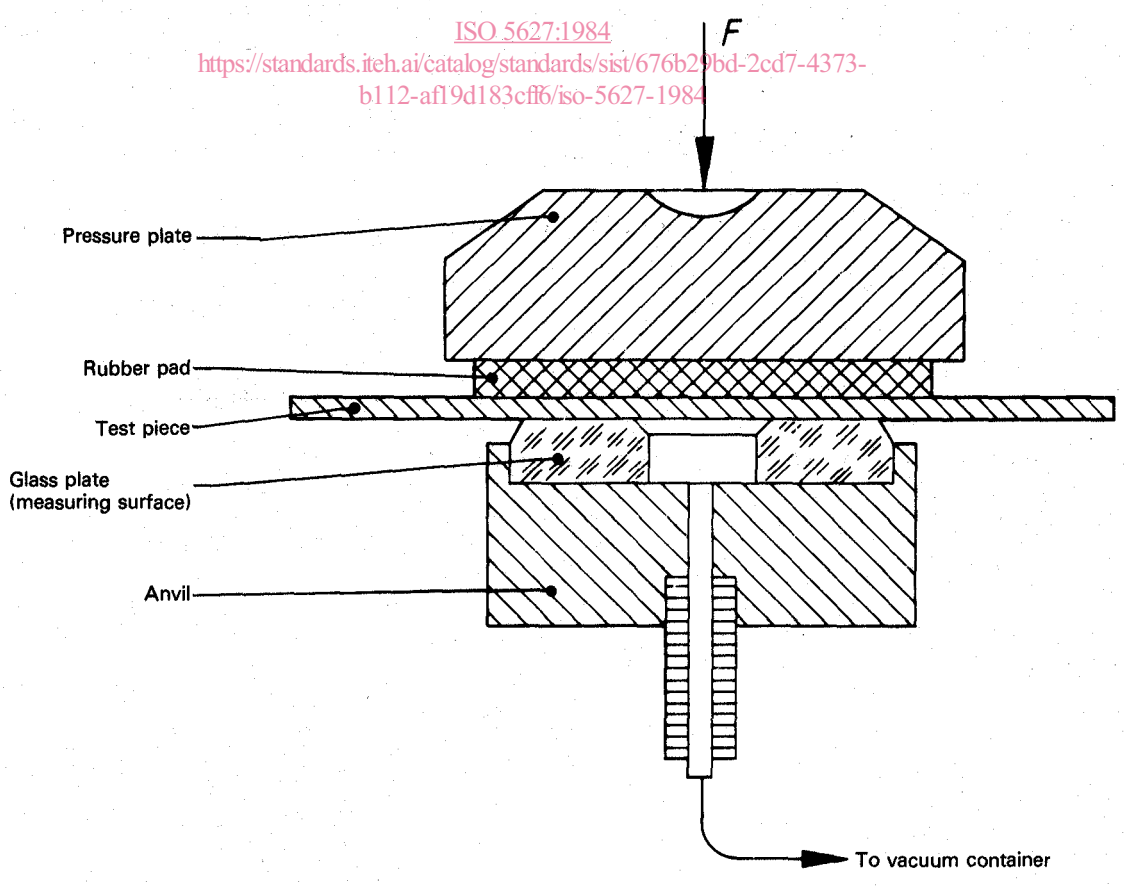

Figure 1 — Measuring principle

Dimensions in millimetres

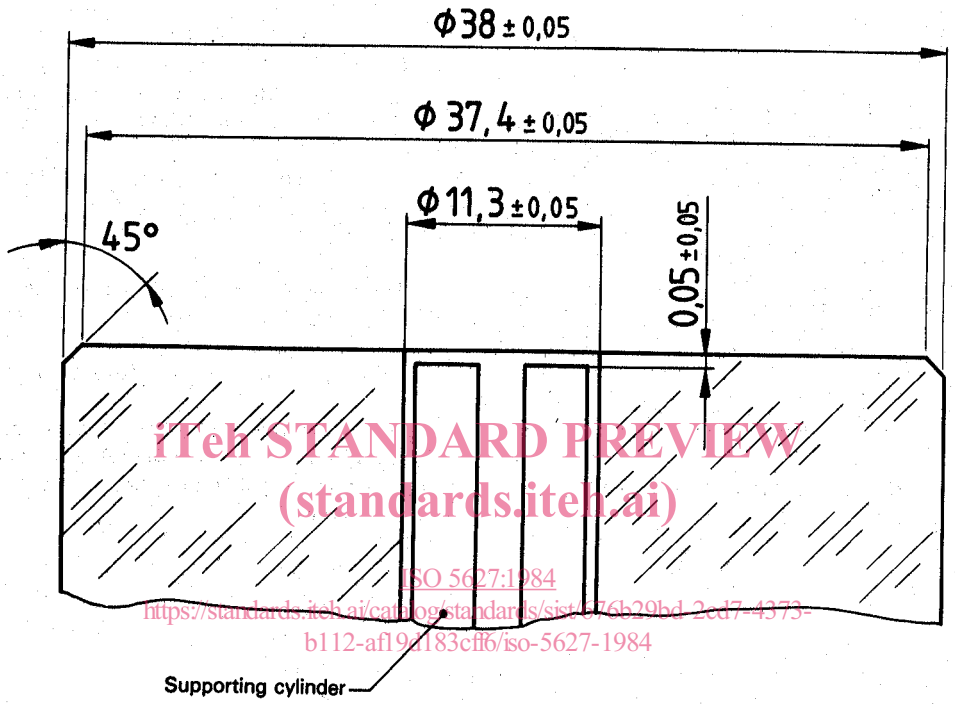

Figure 2 — Glass plate

NOTES

1 Some manufacturers do not provide a glass plate with a bevelled outer edge. In such a case a vertical glass cylinder of diameter 37,4 mm may be used.

2 Glass plates may be available with a bevelled inner edge. In such cases the angle of bevel is 45°.

Annex

Checking and maintenance of the apparatus

(This annex forms part of the Standard.)

A.1 Size of the measuring surface

Measure the diameter of the glass plate and of the hole in it. The permitted tolerances are given in figure 2.

A.2 Contact pressure

In the known instruments the loading is applied by a lever, the operation of which can be tested as follows :

Clamp the apparatus firmly to the table then disconnect the vacuum container. Check the horizontal position of the loading lever on the level. Attach a steel wire to the loading lever precisely above the centre of the hole in the measuring surface and measure the force exerted at that point preferably using a lever balance. The force should be 100 ± 2 N. If different, the force shall be adjusted to this value.

A.3 Graduation of the mercury manometer

Check the graduation of the mercury manometer in the usual way by means of a gauge. The distance between the marks for 50,66 kPa and 48,00 kPa shall be accurate to within 0,1 mm. The distance between the mark for 50,66 kPa and level of the mercury reservoir shall be maintained within ± 0,5 mm.

A.4 Maintenance of the mercury manometer

The mercury shall not remain tailing on the walls of the capillaries. If a jerky dropping of the column is observed, clean the manometer tube alternately with nitric acid and with potassium dichromate dissolved in concentrated sulphuric acid, then rinse with distilled water and afterwards with alcohol. Before reuse, dry the capillary carefully in a current of warm air or by gentle warming.

Soiled mercury should preferably be replaced by fresh material, or it may be cleaned. Suitable safety precautions shall be taken when handling or cleaning mercury.

A.5 Air-tightness of the apparatus

Check the air-tightness of the apparatus at regular intervals. When the rubber pad is pressed directly against the measuring surface with a surface pressure of 100 kPa, a vacuum set at 50,66 kPa in the vacuum container connected to the hole in the glass plate shall not be reduced by more than 0,13 kPa in 60 min for the large container or 6 min for the small container. This check shall be made for both vacuum containers.

If these requirements are not met, check the taps and all connecting points and if necessary clean and repair them.

A.6 Volume of air drawn through

As it is difficult to measure the capacity of the vacuum containers directly, it is recommended that the volume of air drawn through should be determined as described below. This check shall be made on new apparatus and whenever parts of the apparatus, such as the manometer tube, have been cleaned or changed. The values for the volumes of air are :

- for the large vacuum container and vacuum drop from 50,66 to 48,00 kPa : 10,0 ± 0,2 ml;
- for the large vacuum container and vacuum drop from 50,66 to 29,33 kPa : 80,0 ± 1 ml;
- for the small vacuum container and vacuum drop from 50,66 to 48,00 kPa : 1,00 ± 0,05 ml.

The measuring device is illustrated in figure 3. A rubber pad with a hole of about 0,5 mm diameter is attached to the centre piece which is pressed against the glass plate by means of the loading device. The centre piece is connected to a three-way cock by a vacuum tube, and the cock is connected to a measuring pipette of suitable size and graduation also by a vacuum tube.

After the air-tightness of the measuring device has been checked, measure the volume of distilled water that has been drawn into the measuring pipette with the vacuum drop and vacuum container combination existing at the time. Before taking the reading, dip the measuring pipette into the upright cylinder until the water levels in the upright cylinder and the measuring pipette are approximately equal. Use the three-way cock to empty the measuring pipette after a measurement has been made.

This arithmetic mean of 20 measurements shall conform to the stated values.

A.7 Changing the rubber pad

Replace the rubber pad by a new one when comparative measurements with a new pad show statistically significant differences. Three months to 1 year may be regarded as a guide to a valid period of use.

A.8 Air resistance connecting tubes

When the vacuum container is connected to the uncovered hole in the glass plate, the vacuum pressure shall drop from 50,66 kPa to 29,33 kPa within 2 s. This check shall be made for both containers if fitted.

If this requirement is not met, clean the connecting tubes and three-way cock.

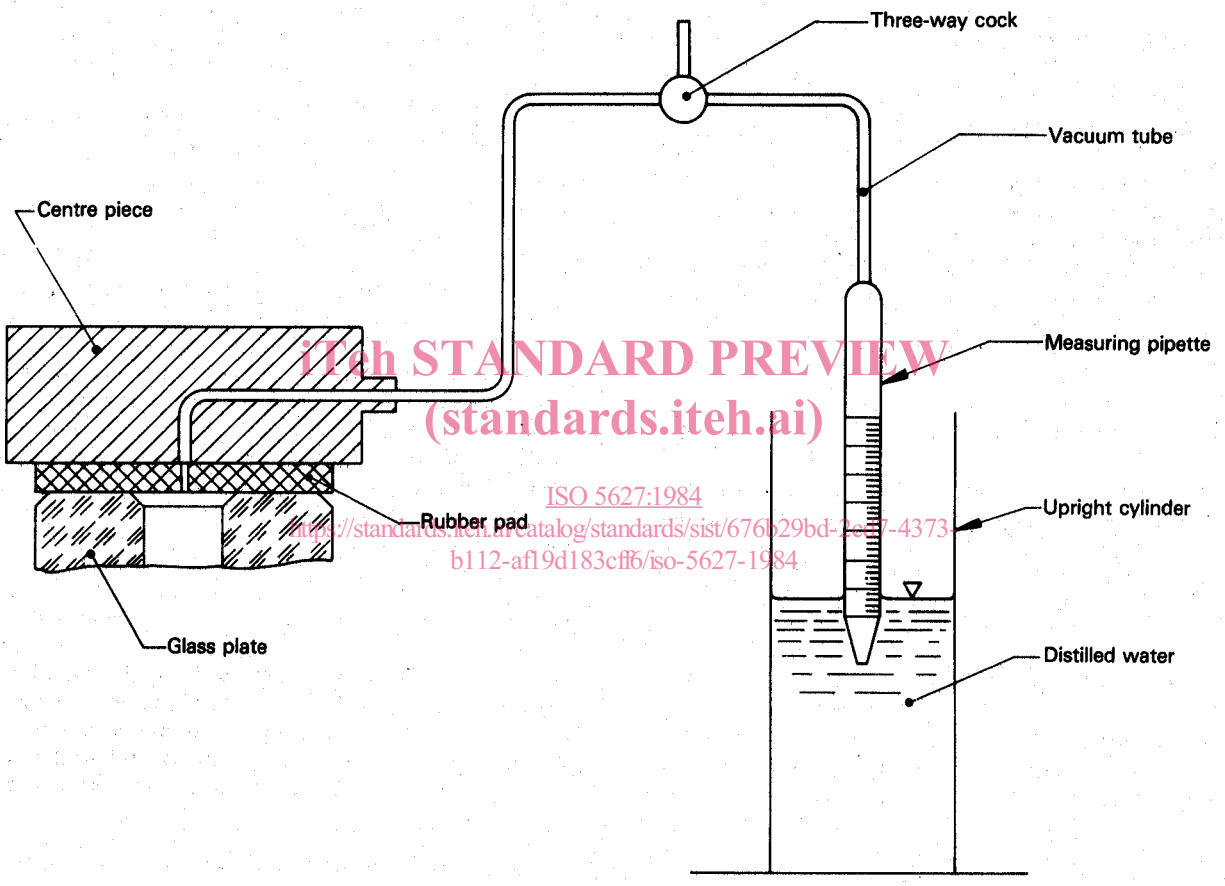

Figure 3 — Measuring device for the volume of air drawn through