International Standard 5530/4

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Wheat flour — Physical characteristics of doughs — Part 4 : Determination of rheological properties using an alveograph

Farines de blé tendre — Caractéristiques physiques des pâtes — Partie 4 : Détermination des caractéristiques rhéologiques au moyen de l'alvéographe

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First edition — 1983-06-01

ISO 5530-4:1983
https://standards.iteh.ai/catalog/standards/sist/b53ee243-0600-4fbe-ae0c-58dee28f80c5/iso-5530-4-1983

UDC 664.641.016 **Ref. No. ISO 5530/4-1983 (E)**

Descriptors : agricultural products, corn (G.B), cereal products, flour (food), doughs, tests, determination, physical properties, test results.

Price based on 7 pages

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.

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International Standard ISO 5530/4 was developed by Technical Committee ISO/TC 34, *Agricultural food products*, and was circulated to the member bodies in November 1981.

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

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Chile	Israel	Tanzania
Czechoslovakia	Italy	United Kingdom
Egypt, Arab Rep. of	Malaysia	USSR
Ethiopia	New Zealand	Yugoslavia
France	Poland	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Ireland
Philippines

NOTE — This International Standard is based on Standard No. 121 of the International Association for Cereal Chemistry (ICC).

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Printed in Switzerland

Wheat flour — Physical characteristics of doughs — Part 4 : Determination of rheological properties using an alveograph

0 Introduction

The rheological properties of doughs made from wheat flour constitute an important factor in their utilization value (for breads, rusks and biscuits).

Throughout the transformation process from wheat into bread or other products, the rheological properties of doughs have important applications :

— judging the quality of new varieties and estimating the utilization value of commercial wheats;

— determining the proportions of different wheats in mixtures before milling and checking the latter;

— defining commercial types of flour, determining the proportions of various flours in a mixture and the constancy of mixing.

Determinations using other types of apparatus (farinograph, extensograph, valorigraph) will form the subjects of parts 1, 2 and 3 of this International Standard.

1 Scope and field of application

This part of ISO 5530 specifies a method, using an alveograph,[1] of determining certain rheological properties of doughs made from wheat flour (*Triticum aestivum*).

2 References

ISO 660, *Animal and vegetable fats and oils — Determination of acid value and of acidity.*[2]

ISO 712, *Cereals and cereal products — Determination of moisture content (Routine reference method).*

ISO 2170, *Cereals and pulses — Sampling of milled products.*

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3 Principle

Preparation of a dough of constant moisture content from wheat flour and salt water, under specified conditions. Preparation of test pieces of standard thickness from the dough. Biaxial extension by inflating into the shape of a bubble. Plotting of the differences in pressure inside the bubble as a function of time. Assessment of the properties of the dough from the surface area under the curve and the shape of the curve obtained.

4 Reagents

4.1 Sodium chloride solution.

Dissolve 25 g of sodium chloride, of recognized analytical quality, in distilled water or water of equivalent purity and make up to 1 000 ml.

4.2 Paraffin oil, sold by pharmacists under the name of *petrolatum liquidum* (liquid paraffin), which is a purified mixture of natural, liquid saturated hydrocarbons obtained from petroleum, with an acid value less than or equal to 0,05. Use paraffin oil having the lowest possible viscosity [not more than 60 mPa·s (60 cP) at 20 °C], or **oleic vegetable oil** with an acid value less than 0,4 (see ISO 660), for example refined African groundnut oil.

1) This International Standard has been drawn up on the basis of the Chopin alveograph (see figure 1), which is the only apparatus of this type presently available.

The manufacturer provides, with the apparatus, a burette graduated in percentages for the moisture content of flour, a planimetric scale and a scale allowing the extent of inflation to be measured.

2) At present at the stage of draft. (Revision of ISO/R 660-1968.)

5 Apparatus

5.1 Alveograph[1] (with temperature regulator) having the following characteristics :

— Rotational frequency of the mixer blade 59 ± 1 min^{-1}

NOTE — Some older models have a rotational frequency of 60 ± 1 min^{-1}. This difference will not, however, have any effect on the results.

— Height of the sheeting guides 12,0 ± 0,1 mm

— Diameter of the sheeting roller : large diameter 40,0 ± 0,1 mm

— Diameter of the sheeting roller : small diameter 33,3 ± 0,1 mm

— Inner diameter of the dough cutter 46,0 ± 0,5 mm

— Diameter of the opening in the moving plate (diameter of the test piece subjected to inflation) 55,0 ± 0,1 mm

— Theoretical distance between the fixed and moving plates once they have been clamped down (equal to the thickness of the test piece before inflation) 2,67 ± 0,01 mm

— Volume of the glass burette between index marks 0 and 25 625 ± 10 ml

— Volume of the rubber pear-shaped bulb 18 ± 2 ml

— Time for emptying the burette between the index marks 0 and 25 23,0 ± 0,5 s

— Linear speed of the periphery of the recording drum 5,5 ± 0,1 mm/s

5.2 Burette, of capacity 160 ml, graduated in 0,25 ml intervals, or a burette graduated directly in percentages of moisture content from 11,6 to 17,8 % (accuracy 0,1 %).

5.3 Balance, accurate to 0,5 g.

5.4 Timer.

5.5 Planimeter and/or **planimetric scale.**[1]

6 Sampling

Carry out sampling by the method specified in ISO 2170.

7 Procedure

7.1 Preliminary checks

7.1.1 Before each test, check that the temperatures of the mixer and the alveograph are 24,0 ± 0,2 °C and 25,0 ± 0,2 °C respectively. Regulate the thermostat a sufficient time before use so that these temperatures have stabilized. Also check them while the equipment is in use.

7.1.2 Check regularly that the equipment is sealed (absence of hydraulic leakage or air leakage).

7.1.3 Check that the water level in the burette is at index mark 0.

7.1.4 Check regularly the rate at which water rises in the burette H. The time for water to flow between index marks 0 and 25 shall be exactly 23 ± 0,5 s.

7.1.5 Check, using the timer, the period of rotation of the recording drum which shall be exactly 60 s for one revolution with a current of frequency 50 Hz (or 60 Hz for recent apparatus having a motor of this type)(or 55 s from stop to stop).

NOTE — This corresponds to a linear chart travel of 302,5 mm in 55 s.

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7.2 Preliminary operations

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7.2.1 Determine the moisture content of the flour by the method specified in ISO 712.

7.2.2 If necessary, bring the temperature of the flour to 20 ± 5 °C. The apparatus shall be used in a room where the temperature is between 18 and 22 °C and the relative humidity is (65 ± 15) %.

7.2.3 Determine, from the table, the quantity of the sodium chloride solution (4.1) to be used in 7.3.1 to prepare the dough.

The values in the table have been calculated to obtain constant hydration, i.e. that of a dough made from 50 ml of sodium chloride solution (4.1) and 100 g of flour with a moisture content of 15 %.

7.3 Mixing the dough

7.3.1 Place 250 g of flour, weighed to the nearest 0,5 g, in the mixer. Secure the lid by tightening the two screws. Connect the mixing blade to the speed reducer. Start the motor and the timer. Pour in the required quantity of sodium chloride solution (4.1) (see the table) in about 20 s through the hole in the lid.

Leave the dough to form for 1 min (including the 20 s for pouring).

1) This International Standard has been drawn up on the basis of the Chopin alveograph (see figure 1), which is the only apparatus of this type presently available.

The manufacturer provides, with the apparatus, a burette graduated in percentages for the moisture content of flour, a planimetric scale and a scale allowing the extent of inflation to be measured.

7.3.2 After this 1 min period, stop the motor and remove the cover. Using a spatula, incorporate the flour and dough adhering to the cover or in the corners with the dough, so that all the dough undergoes hydration. Complete this operation in 1 min and replace the lid.

7.3.3 After this 1 min period (total 2 min), restart the motor. Allow mixing to continue for 6 min.

7.3.4 After a total time of 8 min, stop mixing and proceed with the extrusion.

Table — Volume of sodium chloride solution to be added as a function of the moisture content of the flour

Moisture content of flour	Volume of sodium chloride to be added to 250 g of flour, ml	Moisture content of flour	Volume of sodium chloride to be added to 250 g of flour, ml	Moisture content of flour	Volume of sodium chloride to be added to 250 g of flour, ml
5,0	169,6	10,0	147,2	15,0	125,0
5,1	169,2	10,1	146,8	15,1	124,6
5,2	168,7	10,2	146,3	15,2	124,1
5,3	168,3	10,3	145,9	15,3	123,7
5,4	167,8	10,4	145,5	15,4	123,2
5,5	167,4	10,5	145,1	15,5	122,8
5,6	166,9	10,6	144,6	15,6	122,3
5,7	166,5	10,7	144,2	15,7	121,9
5,8	166,0	10,8	143,7	15,8	121,4
5,9	165,6	10,9	143,3	15,9	121,0
6,0	165,1	11,0	142,8	16,0	120,6
6,1	164,7	11,1	142,4	16,1	120,2
6,2	164,2	11,2	141,9	16,2	119,7
6,3	163,8	11,3	141,5	16,3	119,3
6,4	163,3	11,4	141,0	16,4	118,8
6,5	162,9	11,5	140,6	16,5	118,4
6,6	162,4	11,6	140,1	16,6	117,9
6,7	162,0	11,7	139,7	16,7	117,5
6,8	161,5	11,8	139,2	16,8	117,0
6,9	161,1	11,9	138,8	16,9	116,6
7,0	160,6	12,0	138,3	17,0	116,1
7,1	160,2	12,1	137,9	17,1	115,7
7,2	159,7	12,2	137,5	17,2	115,2
7,3	159,3	12,3	137,1	17,3	114,8
7,4	158,8	12,4	136,6	17,4	114,3
7,5	158,4	12,5	136,2	17,5	113,9
7,6	157,9	12,6	135,7	17,6	113,4
7,7	157,5	12,7	135,3	17,7	113,0
7,8	157,0	12,8	134,8	17,8	112,5
7,9	156,6	12,9	134,4	17,9	112,1
8,0	156,1	13,0	133,9	18,0	111,7
8,1	155,7	13,1	133,5	18,1	111,3
8,2	155,2	13,2	133,0	18,2	110,8
8,3	154,8	13,3	132,6	18,3	110,4
8,4	154,4	13,4	132,1	18,4	109,9
8,5	153,9	13,5	131,7	18,5	109,5
8,6	153,5	13,6	131,2	18,6	109,0
8,7	153,1	13,7	130,8	18,7	108,6
8,8	152,6	13,8	130,3	18,8	108,1
8,9	152,2	13,9	129,9	18,9	107,7
9,0	151,7	14,0	129,4	19,0	107,2
9,1	151,3	14,1	128,9	19,1	106,8
9,2	150,8	14,2	128,6	19,2	106,3
9,3	150,4	14,3	128,2	19,3	105,9
9,4	149,9	14,4	127,7	19,4	105,4
9,5	149,5	14,5	127,3	19,5	105,0
9,6	149,0	14,6	126,8	19,6	104,5
9,7	148,6	14,7	126,4	19,7	104,1
9,8	148,1	14,8	125,9	19,8	103,7
9,9	147,7	14,9	125,5	19,9	103,3

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7.4 Preparation of test pieces

7.4.1 Reverse the direction of rotation of the mixing blade. Open the extrusion aperture by raising the slide of the shutter and place a few drops of oil (4.2) on to the receiving plate previously positioned in place. Discard the first 2 cm of the dough.

7.4.2 When the strip of extruded dough reaches the line indicated by the small indented notches on the plate, rapidly cut the dough with a backwards-and-forwards movement against the guide. Slide the piece of dough on to the glass plate of the sheeting system which shall have been previously oiled.

7.4.3 Repeat the operation described in 7.4.2 three times and leave the fifth piece of dough on the receiving plate. Stop the motor of the mixer.

7.4.4 When two pieces of dough have been placed on the plate of the first sheeting system, sheet them by means of the previously oiled steel roller, running it along the rails 12 times in succession (3 rapid backwards-and-forwards movements followed by three slower ones). Repeat these operations with two other pieces of dough on the second sheeting system.

Cut, in a clean movement, dough test pieces from the pieces of dough using the cutter. Cut away the surplus dough. Lift the cutter containing the dough test piece, tilting it above the resting plate intended to receive the test piece. If the dough sticks to the sides of the cutter, free it from below. If the test piece sticks to the glass, lift it up slightly and slide the resting plate under it. Immediately place each resting plate in the isothermal compartment (at 25 °C) of the alveograph. Proceed in the order of extrusion, the first test piece being placed on top. Remove the fifth dough piece from the receiving plate and repeat these operations.

NOTE — After some experience, it is possible and preferable to carry out the operations described in 7.4.3 and 7.4.4 continuously in one sheeting system while the strip of dough is being extruded.

7.5 Alveograph test on dough test pieces

7.5.1 Leave the dough to stand, and place a sheet of recording paper on the recording drum. Fill the pen with ink, trace the zero pressure line and replace the drum at its starting position.

7.5.2 Start the test 28 min after mixing began.

First operation :

Switch lever A to position 1 (see figure 1).

Raise the upper plate B by rotating it through two revolutions.

Remove ring C and stopper D.

Oil the fixed plate E and inner face of stopper D.

Slide the dough test piece to the centre of E.

Replace D and C.

Flatten the dough test piece by slowly lowering B (2 turns in 20 s).

Wait for 5 s.

Remove ring C and stopper D to free the dough test piece.

Second operation :

Switch lever A to position 2.

Open tap F.

Squeeze the rubber bulb between the thumb and the index finger and maintain the pressure. The dough test piece should detach itself from the plate. If it does not, slide it gently by pushing against its edge with the finger.

Close tap F and release the bulb.

Place the water reservoir H on the platform J.

Third operation :

Switch lever A to position 3 so that the dough test piece starts to inflate and the recording drum starts to revolve.

Switch lever A to position 4 as soon as the dough bubble ruptures.

Replace the water reservoir H on the work table.

Return lever A to position 1 and the recording drum to its original position.

7.5.3 Repeat the operations described in 7.5.2 on the four remaining dough test pieces.

Thus, five curves having the same origin are obtained.

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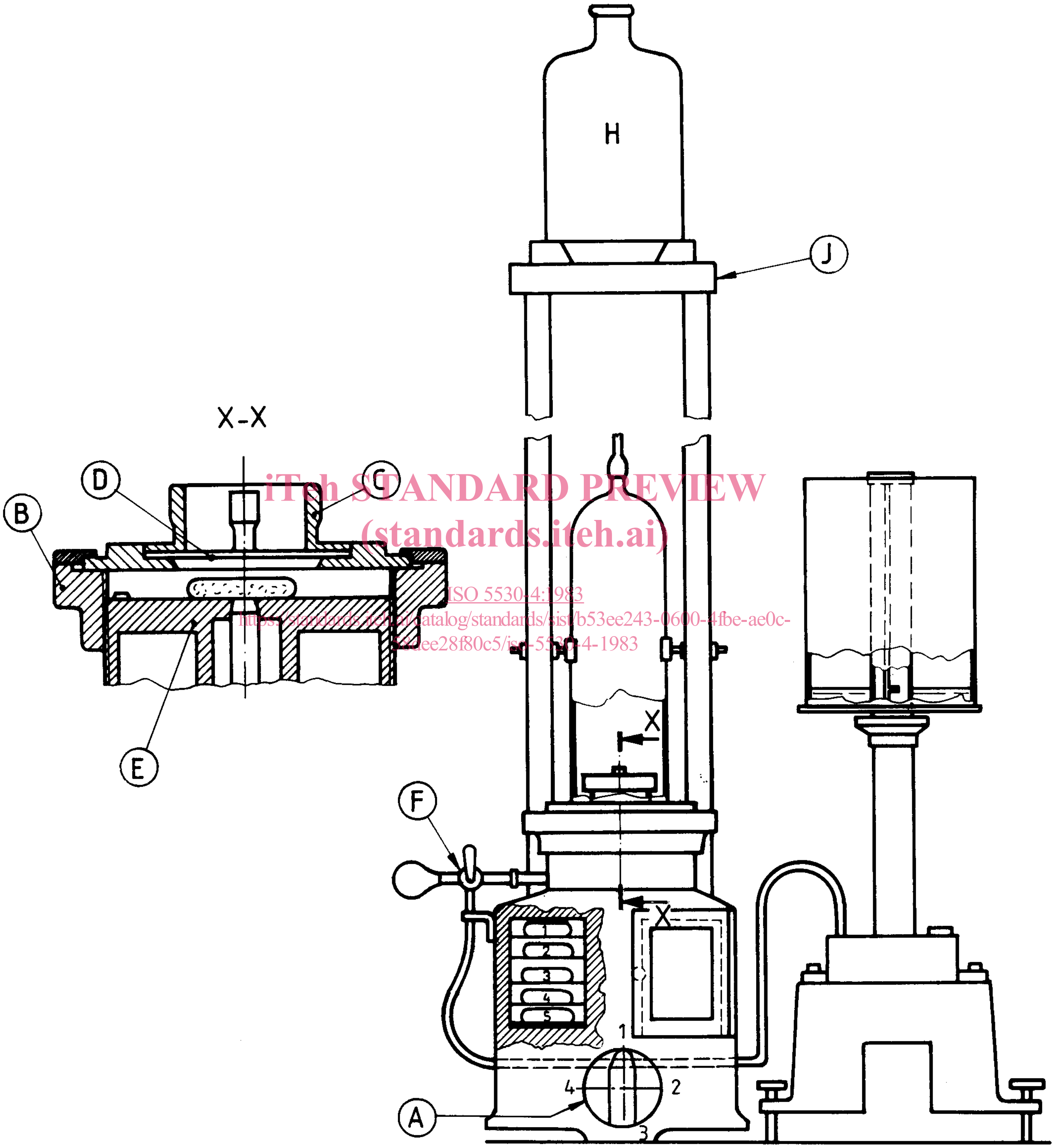

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Figure 1 — Alveograph

8 Expression of results

8.1 General

The results are measured or calculated from the five curves obtained. However, if one of the curves deviates greatly from the other four, particularly as a result of premature rupture of the bubble, it shall not be taken into account in the expression of results (see figure 2).

8.2 Maximum overpressure P

The average of the maximum ordinates, measured in millimetres and multiplied by 1,1, represents the value of the maximum overpressure P which is related to the resistance of the dough to deformation.

8.3 Average abscissa at rupture L

The abscissa at rupture of each curve is measured in millimetres on the zero line, starting from the origin of the curve up to the point corresponding vertically with the clear drop in pressure due to the rupture of the bubble. The average of the abscissae at the rupture point of the curves represents length L.

8.4 Index of swelling G

This is the average of the swelling indices read from the swelling scale and corresponding with the rupture abscissae. Its value is the square root of the volume of air, expressed in millilitres, that is necessary to inflate the bubble until it ruptures (not including the volume of air necessary to detach the dough test piece).

8.5 P/L ratio

This ratio is conventionally called the curve configuration ratio.

8.6 Deformation energy W

An average curve is drawn on the basis of the averages of the ordinates up to the average abscissa at rupture L : this replaces the real curves in the calculations which follow. The area under the curve, in square centimetres, is measured with a planimetric scale or with a planimeter.

The deformation energy of the dough necessary for inflation of the bubble until it ruptures, related to 1 g of dough, represented by the symbol W, and expressed in 10^{-4} J, is calculated in the following manner :

Reference calculation : $W = 1{,}32 \times \frac{V}{L} \times S$

where

V is the volume of air, in millilitres, equal to the square of the swelling index G;

L is the average abscissa at rupture, in millimetres;

S is the area under the curve, in square centimetres.

Practical calculation : For most commonly used flours having swelling indices G between 12 and 26, the indices being measured by means of the scale, the following simplified formula may be used :

$$W = 6{,}54 \times S$$

This coefficient is valid for :

a) a drum rotation time of 55 s from stop to stop;

b) a water flow period in the burette of 23 s between index marks 0 and 25.

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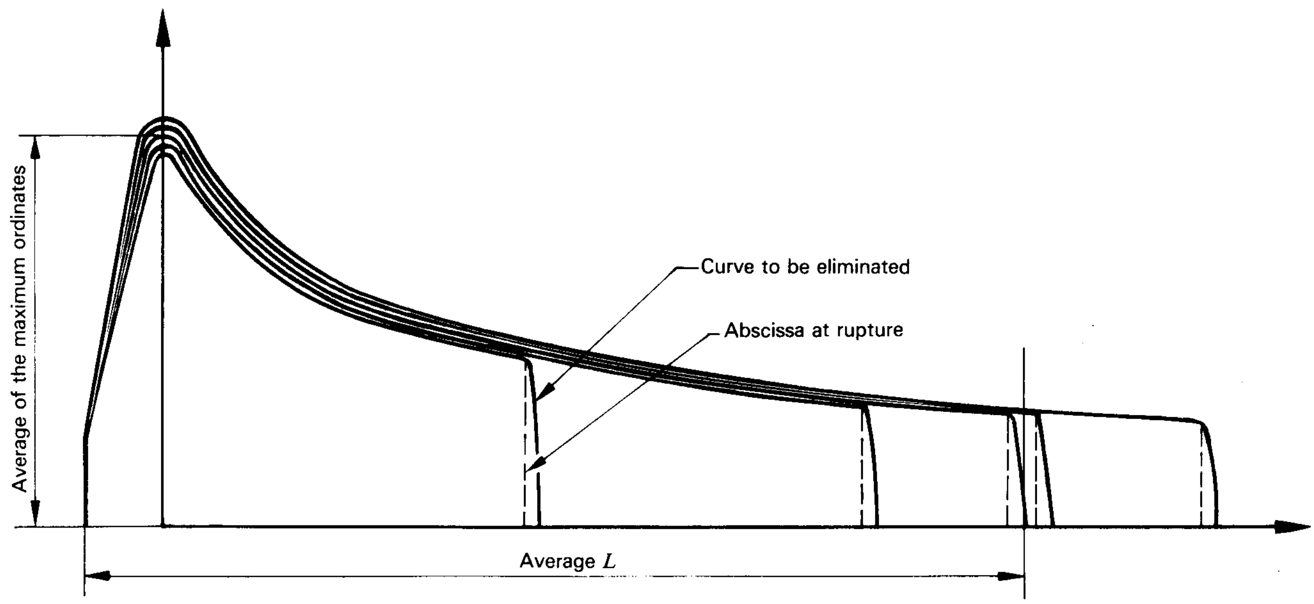

Figure 2 — Alveograph — Curves obtained during a test

8.7 Results

The results shall be considered as the results of a technological test and expressed in the following manner :

P and *L* to the nearest unit (without decimal fractions of millimetres);

G to the nearest 0,5 unit (for example : 23 — 23,5 — 24...),

W to the nearest 5 units for flours with values of *W* less than 200 (for example, scale of values : 150 — 155 — 160 — 165...), or to the nearest 10 units for flours with values of *W* greater than 200 (for example, scale of values : 250 — 260 — 270 — 280...).

9 Precision

9.1 Reproducibility

The reproducibility of the results depends on three principal factors :

— accuracy of the determination of the moisture content of the flour;

— strict adherence to the experimental procedures and the checks laid down in the instruction manual supplied with the apparatus;

— good mechanical state of the different parts of the apparatus.

As an example, reproducibility under normal conditions can be estimated as follows :

W	coefficient of variation	8 %
P	coefficient of variation	8 %
G	coefficient of variation	5 %

9.2 Repeatability

Under the best circumstances, repeatability may be substantially lower than the values indicated in 9.1.

10 Test report

The test report shall show the method used and the results obtained. It shall also mention all operating details not specified in this International Standard, or regarded as optional, as well as any circumstances likely to have influenced the results.

The test report shall give all the details required for the complete identification of the sample.

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