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Second edition
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Cereals and cereal products — Common wheat (*Triticum aestivum* L.) — Determination of alveograph properties of dough at constant hydration from commercial or test flours and test milling methodology

*Céréales et produits céréaliers — Blé tendre (*Triticum aestivum* L.) — Détermination des propriétés alvéographiques d'une pâte à hydratation constante de farine industrielle ou d'essai et méthodologie pour la mouture d'essai*

Reference number
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Foreword

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The committee responsible for this document is ISO/TC 34, *Food products*, Subcommittee SC 4, *Cereals and pulse*.

This second edition cancels and replaces the first edition (ISO 27971:2008), which has been technically revised.

Introduction

The end-use value of wheat is determined by a number of properties that are useful in the manufacture of baked products such as bread, rusks, and biscuits.

Such properties include the important viscoelastic (rheological) properties of dough formed as a result of flour hydration and kneading. An alveograph is used to study the main parameters by subjecting a dough test piece to biaxial extension (producing a dough bubble) by inflating it with air, which is similar to the deformation to which it is subjected during panary fermentation.

Recording the pressure generated inside the bubble throughout the deformation of the dough test piece until it ruptures provides information on the following:

a) the resistance of the dough to deformation, or its strength. It is expressed by the maximum pressure parameter, P;

b) the extensibility or the possibility of inflating the dough to form a bubble; It is expressed by the parameters of extensibility, L, or swelling, G;

c) the elasticity of the dough during biaxial extension. It is expressed by the elasticity index, I_e;

d) the work required to deform the dough bubble until it ruptures, which is proportional to the area of the alveogram (sum of the pressures throughout the deformation process). It is expressed by the parameter, W.

The P/L ratio is a measurement of the balance between strength and extensibility.

Alveographs are commonly used throughout the wheat and flour industry, for the following purposes:

— selecting and assessing different varieties of wheat and marketing batches of wheat;

— blending different batches of wheat or flour to produce a batch with given values for the alveographic criteria (W, P, and L) complying with the proportional laws of blending.

Alveographs are used both on the upstream side of the industry for marketing, selecting and assessing the different wheat varieties and on the downstream side throughout the baking industries (see Bibliography).

Cereals and cereal products — Common wheat (*Triticum aestivum* L.) — Determination of alveograph properties of dough at constant hydration from commercial or test flours and test milling methodology

1 Scope

This International Standard specifies a method of determining, using an alveograph, the rheological properties of different types of dough obtained from common wheat flour (*Triticum aestivum* L.) produced by industrial milling or laboratory milling.

It describes the alveograph test and how to use a laboratory mill to produce flour in two stages:

— stage 1: preparation of the wheat grain for milling to make it easier to separate the bran from the endosperm (see Clause 7);

— stage 2: the milling process, including breaking between three fluted rollers, reduction of particle size between two smooth rollers and the use of a centrifugal sieving machine to grade the products (see Clause 8).

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 660, *Animal and vegetable fats and oils — Determination of acid value and acidity*

ISO 712, *Cereals and cereal products — Determination of moisture content — Reference method*

ISO 12099, *Animal feeding stuffs, cereals and milled cereal products — Guidelines for the application of near infrared spectrometry*

3 Principle

The behaviour of dough obtained from a mixture of different types of flour and salt water is evaluated during deformation. A dough disk is subjected to a constant air flow; at first it withstands the pressure. Subsequently, it inflates into a bubble, according to its extensibility, and ruptures. The change in the dough is measured and recorded in the form of a curve called an alveogram.

4 Reagents

Unless otherwise specified, use only reagents of recognized analytical grade, and only distilled or demineralized water or water of equivalent purity.

4.1 Sodium chloride solution, obtained by dissolving (25 ± 0,2) g of sodium chloride (NaCl) in water and then making the volume up to 1 000 ml. This solution shall not be stored for more than 15 d and its temperature shall be (20 ± 2) °C when used.

4.2 Refined vegetable oil, low in polyunsaturates, such as peanut oil. It is possible to use olive oil if its acid value is less than 0,4 (determined according to ISO 660). Store in a dark place in a closed container and replace regularly (at least every three months).

Alternatively, **liquid paraffin** (also known as "soft petroleum paraffin"), with an acid value of less than or equal to 0,05 and the lowest possible viscosity [maximum 60 mPa·s (60 cP) at 20 °C].

4.3 Cold degreasing agent, optimum safety.

5 Apparatus

Usual laboratory apparatus and, in particular, the following.

5.1 Mechanical cleaner, fitted with sieves for wheat cleaning, in accordance with the manufacturer's instructions.

5.2 Conical or riffle sample divider.

5.3 Analytical balance, accurate to 0,01 g.

5.4 Glass burette, of 50 ml in capacity, graduated in 1 ml divisions.

5.5 Rotary blender[1)], for grain conditioning and flour homogenization, including the following components:

5.5.1 Constant speed stirrer.

5.5.2 Two worm screws integral with the flask, possibly via the stopper (one for wheat preparation, the other for flour homogenization).

5.5.3 Several wide-necked plastic flasks, 2 l capacity.

5.6 Test mill (laboratory mill), manually or automatically operated (see Annex A).

5.7 Complete alveograph system (see Table 1 for specifications and characteristics of the accessories) including the following devices:

5.7.1 Kneading machine [for models MA 82, MA 87, and MA 95, see Figure 1 a); for model NG, see label a in Figure 2 and Figure 3], with accurate temperature control, for dough sample preparation.

5.7.2 Hydraulic manometer or Alveolink[2)] [for models MA 82, MA 87, and MA 95, see Figure 1 b); for model NG, see label b in Figure 2 and Figure 3] for recording the pressure curve.

5.7.3 Alveograph[3)] [for models MA 82, MA 87, and MA 95, see Figure 1 c); for model NG, see label c in Figures 2 and Figure 3] with accurate temperature control, for biaxial deformation of the dough

1) The Chopin MR 2 l rotary blender is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

2) Alveolink is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

3) The methods specified in this International Standard are based on the use of the MA 82, MA 87, MA 95 and NG models of Chopin alveograph which are examples of suitable products commercially available This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

test pieces. It has two rest chambers, each containing five plates on which the dough test pieces can be arranged prior to deformation.

5.8 Burette with stopcock, supplied with the apparatus, 160 ml capacity, graduated in divisions of 0,1 % of moisture content.

NOTE Throughout this International Standard, “content” is expressed as a “mass fraction” (see ISO 80000-9, 12[6]), i.e. the ratio of the mass of substance in a mixture to the total mass of the mixture.

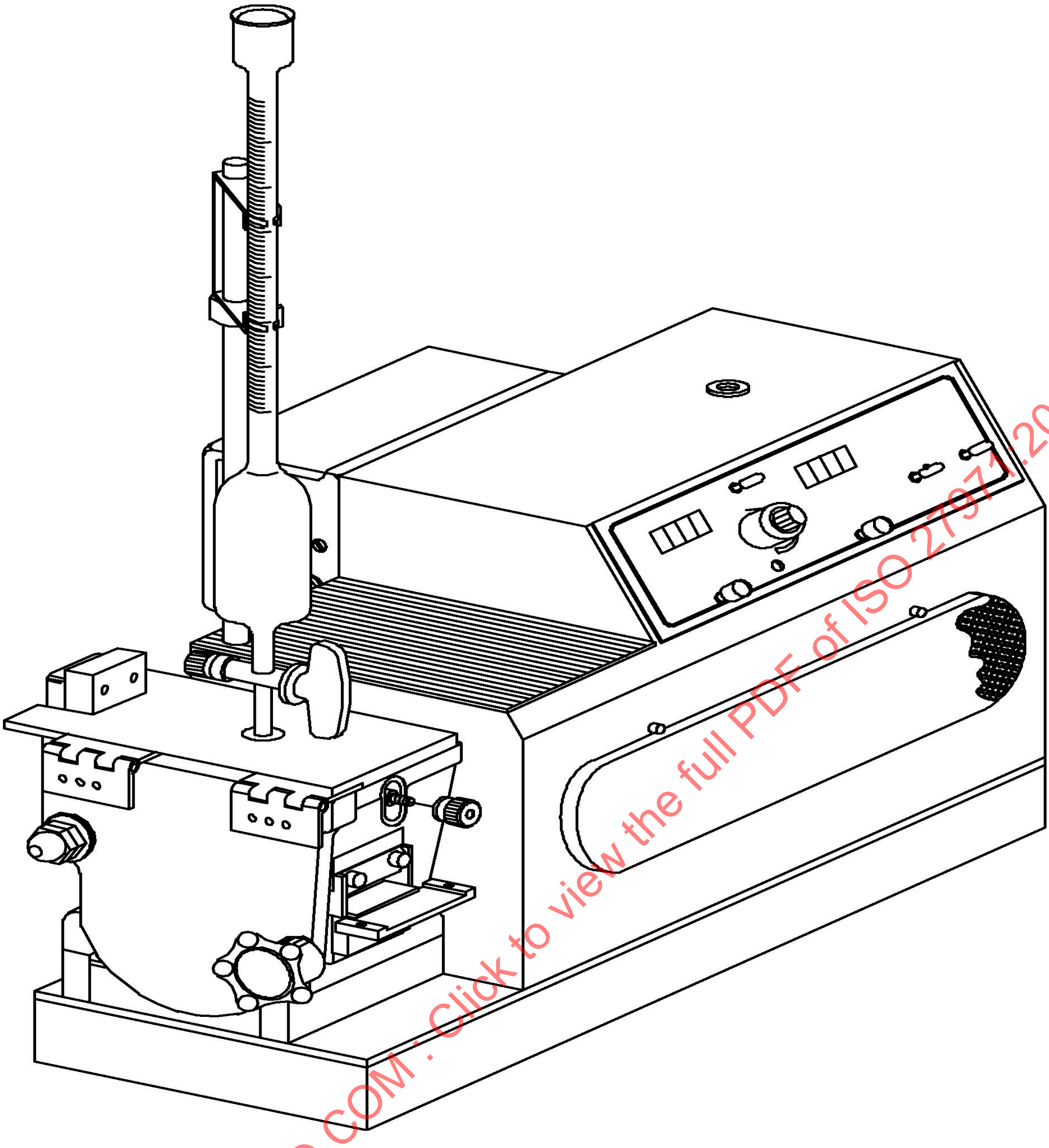
5.9 Timer, for use with model MA 82 only.

5.10 Planimetric scales, supplied with the apparatus where an Alveolink is not included.

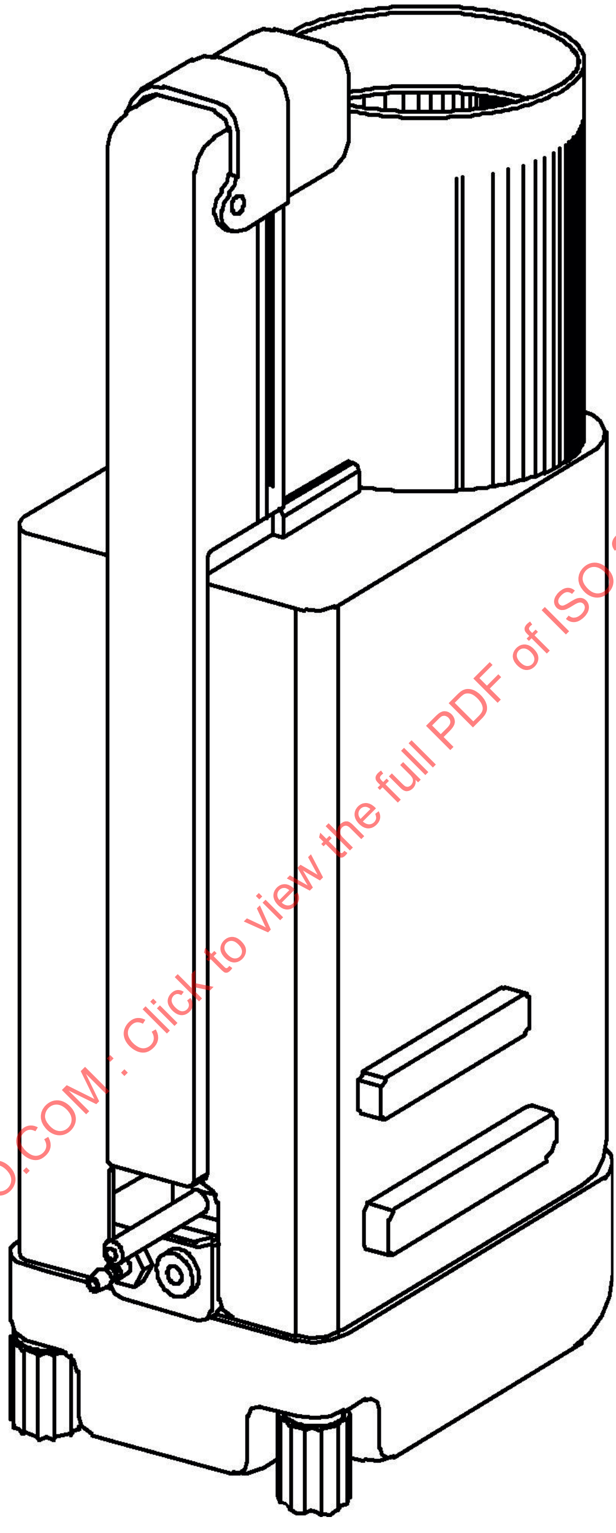
5.11 System for recording the test environment conditions (temperature and relative air humidity) as specified in 8.1 and 9.1.

5.12 Volumetric flask, 1 000 ml capacity, complying with the requirements of ISO 1042, class A.

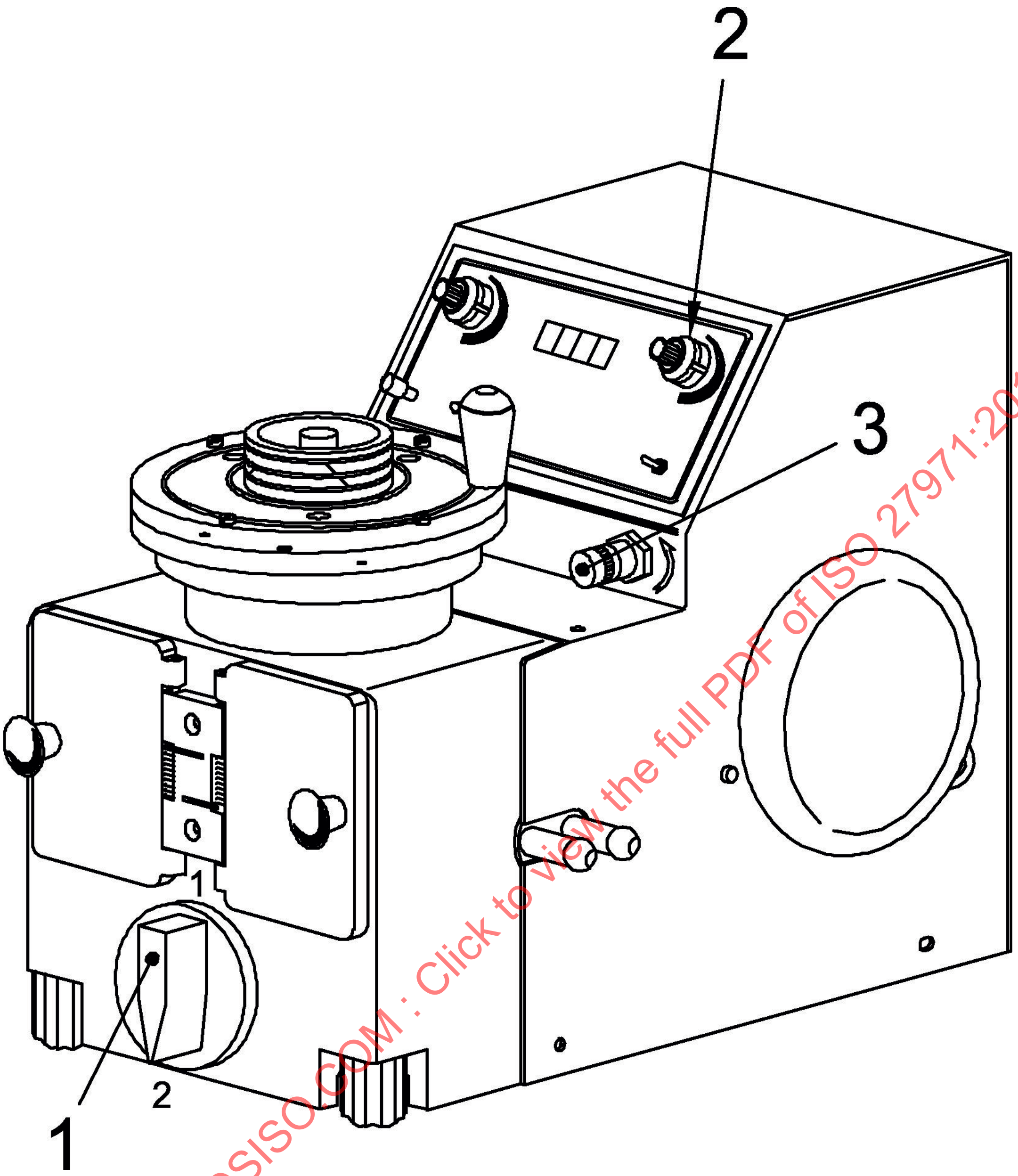
5.13 Pipette, 25 ml capacity, graduated in divisions of 0,1 ml, complying with the requirements of ISO 835, class A.



a) Kneading machine



b) Manometer



c) Alveograph

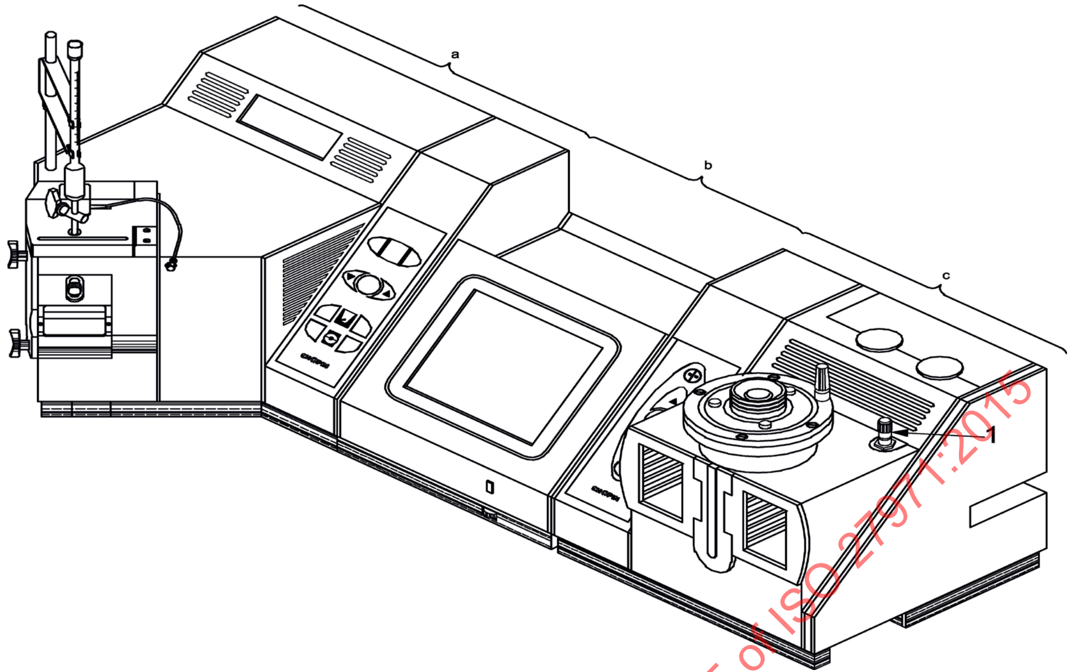
Key

1 handle A in position 2

2 pump potentiometer

3 micrometric valve for air flow adjustment

Figure 1 — Model MA 82, MA 87, and MA 95 alveograph assemblies



Key

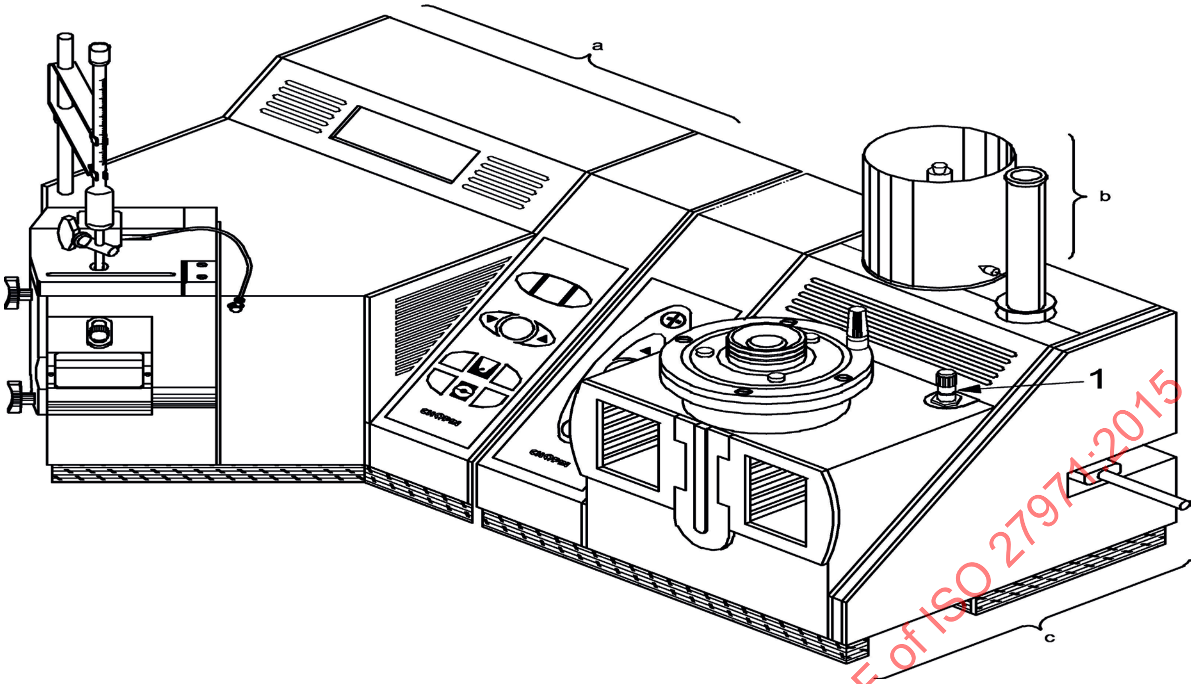
1 micrometric valve for air flow adjustment

a NG kneading machine.

b NG integrator-recorder.

c NG alveograph (with NG integrator-recorder).

Figure 2 — NG alveograph assembly with Alveolink integrator-recorder



Key

1 micrometric valve for air flow adjustment

a NG kneading machine.

b NG recording machine.

c NG alveograph (with hydraulic recording manometer).

Figure 3 — NG alveograph assembly with hydraulic recording manometer

Table 1 — Specifications and characteristics of the accessories required for the test

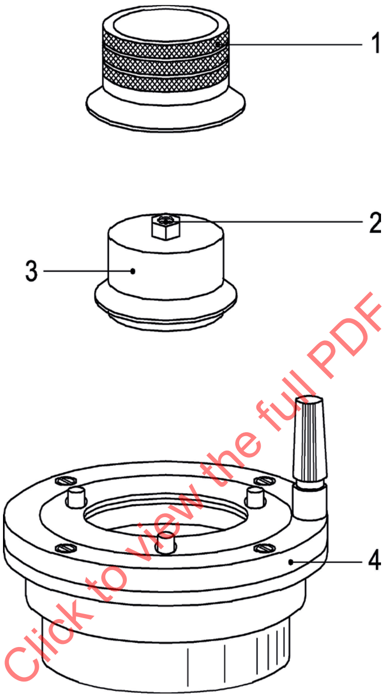
Quantity	Value and tolerance
Rotational frequency of the kneading machine blade	(60 ± 2) Hz
Height of sheeting guides	(12,0 ± 0,1) mm
Large diameter of the sheeting roller	(40,0 ± 0,1) mm
Small diameter of the sheeting roller	(33,3 ± 0,1) mm
Inside diameter of the dough cutter	(46,0 ± 0,5) mm
Diameter of the aperture created when the moving plate opens (which determines the effective diameter of the test piece)	(55,0 ± 0,1) mm
Theoretical distance between the fixed and moving plates after clamping (equal to the thickness of the test piece before inflation)	(2,67 ± 0,01) mm
Volume of air automatically injected to detach the test piece prior to inflating the bubble[a]	(18 ± 2) ml
Linear speed of the periphery of the recording drum	(5,5 ± 0,1) mm/s
Air flow[b] ensuring inflation	(96 ± 2) l/h

[a] Some older devices are fitted with a pear-shaped rubber bulb for manual injection of the 18 ml required to detach the test piece.

[b] To adjust the flow rate of the air generator used to inflate the bubble, fit the nozzle (Figure 4) to create a specified pressure drop (and obtain a pressure corresponding to a height of 92 mmH2O(12,3 kPa) on the manometer chart). The air flow rate is set with the standardized pressure drop to obtain a pressure corresponding to a height of 60 mmH2O(8,0 kPa) on the manometer chart, i.e.(96 ± 2) l/h (see Figure 4 and Figure 5).

Table 1 *(continued)*

Quantity	Value and tolerance
Rotation time of the manometer drum (from stop to stop)	(55 ± 1) s
[a] Some older devices are fitted with a pear-shaped rubber bulb for manual injection of the 18 ml required to detach the test piece.	
[b] To adjust the flow rate of the air generator used to inflate the bubble, fit the nozzle (Figure 4) to create a specified pressure drop (and obtain a pressure corresponding to a height of 92 mmH2O(12,3 kPa) on the manometer chart). The air flow rate is set with the standardized pressure drop to obtain a pressure corresponding to a height of 60 mmH2O(8,0 kPa) on the manometer chart, i.e.(96 ± 2) l/h (see Figure 4 and Figure 5).	



Key

1 knurled ring

2 nozzle

3 nozzle holder

4 top plate

Figure 4 — Flow control system

6 Sampling

A representative wheat or flour sample should have been sent to the laboratory. It shall not have been damaged or changed during transport or storage.

Sampling is not part of the method specified in this International Standard. Recommended sampling methods are given in ISO 24333.[1]

7 Preparation of the wheat for laboratory milling.

7.1 Cleaning the laboratory sample

Pass the laboratory sample through a mechanical cleaner (5.1) to ensure that all stones and metal fragments are removed and to avoid damaging the rollers during milling. A magnetic device may also be used to remove ferrous metal fragments.

7.2 Test portion

The test portion shall be representative of the initial wheat mass. Use the sample divider (5.2) to homogenize and divide the laboratory sample until the mass required for laboratory milling plus moisture content determination is obtained. The minimum wheat mass of the test portion for milling shall be 800 g.

7.3 Wheat moisture content determination

Determine the moisture content of the test portion as specified in ISO 712, or using a rapid device the measurement of which does not differ from the reference value by ±0,4 g water per 100 g of sample (see ISO 7700-1).

7.4 Wheat preparation

7.4.1 General

Preparing the wheat for milling makes it easier to separate the bran from the endosperm. The target moisture content is (16,0 ± 0,5) %.

7.4.2 Wheat with initial moisture content between 13 % and 15 % (one-stage moistening)

Using the balance (5.3), weigh a test portion (minimum 800 g) to the nearest 1 g of wheat and pour it into the blender.

Add the required amount of water (see Table B.1) to the grain from the burette (5.4) directly, or after weighing it to the nearest 0,5 g.

Immediately after adding the water, insert the stopper fitted with the worm screw provided for use with wheat into the flask, shake vigorously for a few seconds and place on the rotary blender (5.5).

Run the rotary blender for (30 ± 5) min (time required to distribute the water evenly across the surface of the grains).

Allow it to rest for a period that brings the total time of the moistening, shaking and resting operations to (24 ± 1) h.

7.4.3 Wheat with a moisture content less than 13 % (two-stage moistening)

As a larger volume of water is required, divide it into two halves and add in two stages during the preparation period.

Proceed as described in 7.4.2, using only half the total quantity of water required (see Table B.1).

Shake the flask as described in 7.4.2 and allow it to rest for at least 6 h.

Then add the second half of the total quantity of water between the 6th hour and the 7th hour.

After adding the second half, shake the flask again for (30 ± 5) min, then allow it to rest for a period that brings the total time of the moistening, shaking and resting operations to (24 ± 1) h.

7.4.4 Wheat with a moisture content greater than 15 % (preliminary drying followed by moistening, as described above)

The wheat shall be dried to produce a moisture content lower than 15 %.

Spread the laboratory sample in a thin layer to optimize the exchange between the grain and the air. Allow to dry in the open air in a dry place for at least 15 h.

Perform the moisture content determination process again (7.3).

Then prepare the wheat as specified in 7.4.2 or 7.4.3, depending on the new moisture content.

8 Laboratory milling

8.1 General

The test mill (5.6) shall be used with the manufacturer's settings. Additional weights shall not be used and the tension on the reduction side spring shall not be changed.

The quality of the milling process depends on several factors:

a) environmental conditions that allow the final moisture content of the flour to be between 15,0 % and 15,8 % (wheat should be milled in an ambient temperature between 18 °C and 23 °C with a relative air humidity between 50 % and 75 %);

b) the condition of the sieves; the sieving area shall remain uniform — if a sieve is pierced, it shall be replaced immediately;

c) beater condition and setting: worn blades reduce the extraction rate;

d) compliance with flow rates: the efficiency of the roll and the efficiency of the sieving process are strictly dependent on a regular feed rate. The speed at which the products pass through the sieving drum can be set by adjusting the position of the blades[4)] on the beaters.

8.2 Milling procedure

8.2.1 Breaking

Switch on the device.

Set the feed rate to allow the conditioned wheat to pass through the mill in (5 ± 1) min.

Pour the conditioned wheat (7.4) into the mill feed hopper and, at the same time, start the timer to check milling time.

After the last grains of wheat have passed through, let the mill continue to operate for (180 ± 30) s to completely clear out the sieve.

When the mill stops, weigh (5.3) separately, the bran, the semolina, and the flour to the nearest 0,1 g.

Calculate the percentage of semolina obtained compared with the mass of wheat used, expressing the result to one decimal place.

8.2.2 Reduction

Switch on the device.

4) Two adjustable blades in the middle and at the end of the beater on the break side, four blades at the end on the reduction side.

Adjust the feed rate to allow the semolina produced in 8.2.1 to pass through the mill in (5 ± 1) min.

Pour the semolina into the feed hopper and, at the same time, start the timer to check the time.

After the last grains of semolina have passed through, let the mill continue to operate for (180 ± 30) s to completely clear out the sieve.

Repeat the above reduction procedure if the mass of semolina obtained from the break system is greater than or equal to 48 %[5)] of the mass of conditioned wheat.

When the mill stops, weigh (5.3) separately, the middlings and the reduction flour to the nearest 0,1 g.

Ensure that the milling ratio, *BM* (ratio of the sum of the masses of the milled products to the total conditioned wheat mass), is equal to at least 98 %.

NOTE A milling ratio less than 98 % indicates excessively worn beaters or an obstruction in the sieves, causing some of the product to remain inside the sieving drum.

8.2.3 Flour homogenization

Pour the break and reduction flour into the blender flask (5.5.3).

Insert the stopper fitted with the worm screw (5.5.2) provided for use with flour into the flask and place the flask on the blender (5.5).

Mix for (20 ± 2) min.

Remove the worm screw (5.5.2) and replace it with the flask stopper. The flour is now ready for the alveograph test.

8.2.4 Storage of the flour

The flask containing the flour shall be kept in the room where the alveograph test is performed.

8.3 Expression of milling results

Calculate the extraction rate, *ER*, as a percentage of dry mass, of flour extracted from the cleaned wheat using Formula (1):

$$ER = \frac{(100 - H_f) \times M_f}{(100 - H_b) \times M_b} \times 100 \qquad (1)$$

where

H_f is the moisture content, as a percentage, of the flour obtained (determined according to ISO 712);

H_b is the moisture content, as a percentage, of the wheat test portion for milling before moistening (determined according to ISO 712);

M_f is the mass, in grams, of the total flour obtained;

M_b is the wheat mass, in grams, of the test portion for milling before moistening.

Express the result to the nearest 0,1 % mass fraction.

5) Round up the values: 47,4 becomes 47 and 47,5 becomes 48.

Calculate the percentage of bran, S, using Formula (2):

$$S = \left[M_s / \left(M_b + M_e \right) \right] \times 100 \tag{2}$$

Calculate the percentage of middlings, R, using Formula (3):

$$R = \left[M_r / \left(M_b + M_e \right) \right] + 100 \tag{3}$$

where

M_s is the mass, in grams, of bran;

M_r is the mass, in grams, of middlings;

M_b is the initial mass, in grams, of the wheat before conditioning;

M_e is the mass, in grams, of water added (numerically equal to the volume, V_e, in millilitres, of water added).

Express the results to the nearest integer.

9 Preparation and alveograph test

9.1 Preliminary checks

Ensure that the ambient temperature is between 18 °C and 22 °C with a relative humidity between 50 % and 80 %.

Ensure that the various components of the apparatus (kneading machine, alveograph, recorder, burette, tools, etc.) are clean.

Check that the F-register is in place in the extrusion aperture to prevent any loss of flour or salt solution leakage.

Ensure that the temperature of the kneading machine (5.7.1) at the start of the test is (24,0 ± 0,5) °C; the temperature of the alveograph shall be continuously set to (25,0 ± 0,5) °C.

NOTE A rise in the kneading machine temperature during the kneading process is normal and characteristic of flour under test. The continuous control feature provided on the NG models should not be used.

Regularly check that the pneumatic circuit on the apparatus is sealed (no air leakage) by following the manufacturer's recommended procedure.

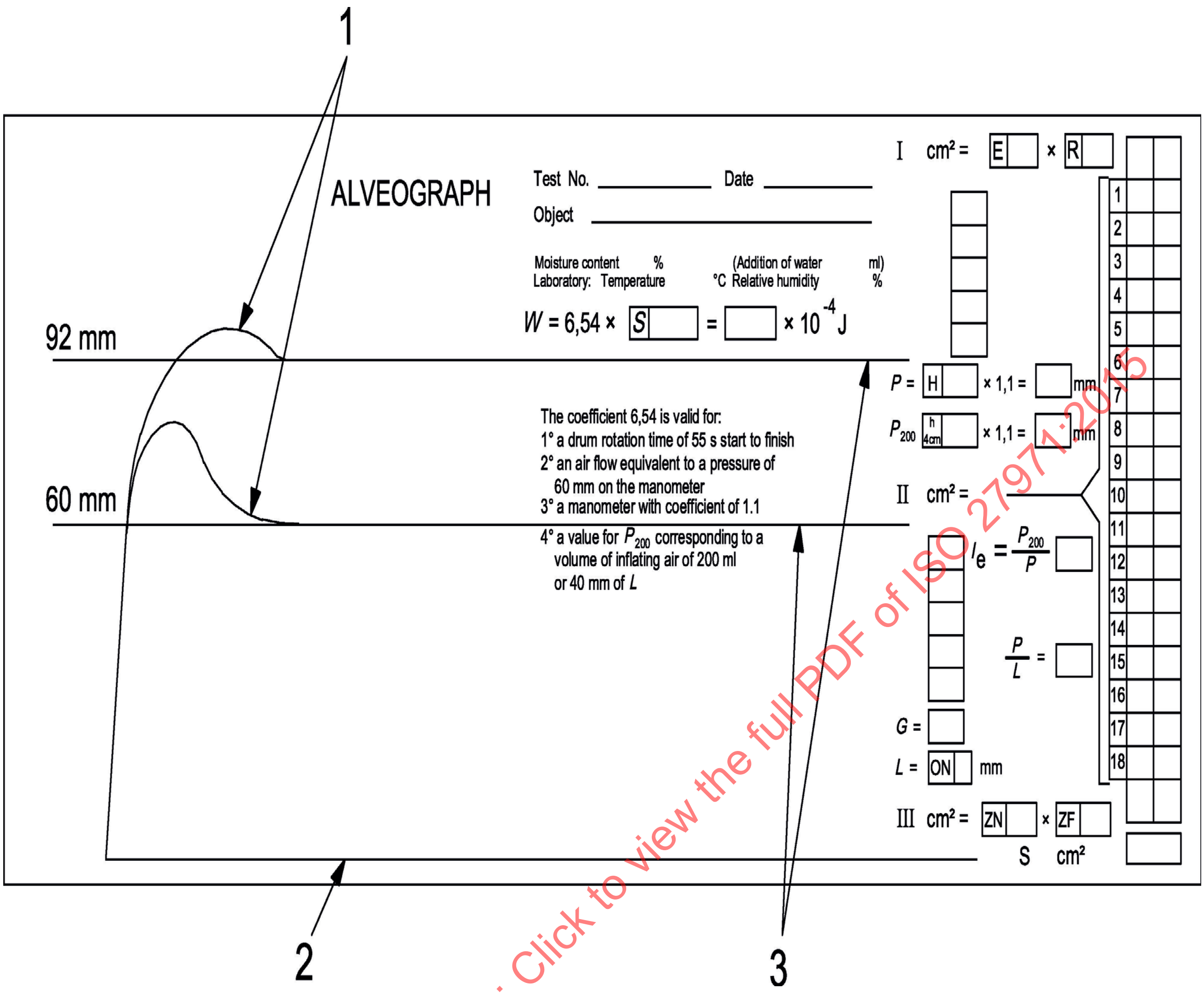
Check the air flow settings using the nozzle (see Table 1, Note b), creating the specified loss of pressure [see Figure 1c), Label 1 in Figures 2 and 3, and Figures 4 and 5] by setting:

a) the air generator to a pressure corresponding to 92 mmH_2O (12,3 kPa) on the hydraulic manometer chart or on the recorder screen;

b) the micrometer flow rate valve to a pressure corresponding to 60 mmH_2O (8,0 kPa) on the manometer chart or the recorder screen.

Check that the alveograph plate is horizontal.

If a recording manometer is employed, use the timer (5.9) to check the rotation time of the recording drum according to the manufacturer's recommended procedure.



Key

1 line of the float

2 zero-pressure base line

3 parallel

Figure 5 — Measurement pressure setting

9.2 Preliminary operations

At the beginning of the test, the temperature of the flour shall be the ambient temperature.

Determine the moisture content of the flour according to the method specified in ISO 712 or with an apparatus using near infrared spectroscopy whose performance has been demonstrated in accordance with ISO 12099 and meets at minima a SEP ≤ 0,15 % determined on the entire scope of this standard. From Table 2, find the quantity of sodium chloride solution (4.1) to be used in 9.3 to prepare the dough.

Table 2 — Volume of sodium chloride solution (4.1) to be added during kneading

Moisture content of the flour %	Volume of solution to be added ml	Moisture content of the flour %	Volume of solution to be added ml	Moisture content of the flour %	Volume of solution to be added ml
8,0	155,9	11,0	142,6	14,0	129,4
8,1	155,4	11,1	142,2	14,1	129,0
8,2	155,0	11,2	141,8	14,2	128,5
8,3	154,6	11,3	141,3	14,3	128,1
8,4	154,1	11,4	140,9	14,4	127,6
8,5	153,7	11,5	140,4	14,5	127,2
8,6	153,2	11,6	140,0	14,6	126,8
8,7	152,8	11,7	139,6	14,7	126,3
8,8	152,4	11,8	139,1	14,8	125,9
8,9	151,9	11,9	138,7	14,9	125,4
9,0	151,5	12,0	138,2	15,0	125,0
9,1	151,0	12,1	137,8	15,1	124,6
9,2	150,6	12,2	137,4	15,2	124,1
9,3	150,1	12,3	136,9	15,3	123,7
9,4	149,7	12,4	136,5	15,4	123,2
9,5	149,3	12,5	136,0	15,5	122,8
9,6	148,8	12,6	135,6	15,6	122,4
9,7	148,4	12,7	135,1	15,7	121,9
9,8	147,9	12,8	134,7	15,8	121,5
9,9	147,5	12,9	134,3	15,9	121,0
10,0	147,1	13,0	133,8	16,0	120,6
10,1	146,6	13,1	133,4		
10,2	146,2	13,2	132,9		
10,3	145,7	13,3	132,5		
10,4	145,3	13,4	132,1		
10,5	144,9	13,5	131,6		
10,6	144,4	13,6	131,2		
10,7	144,0	13,7	130,7		
10,8	143,5	13,8	130,3		
10,9	143,1	13,9	129,9		

NOTE The volume of sodium chloride solution (4.1), V_{NaCl}, to be added during kneading is calculated from the formula:

$V_{NaCl} = 191,175 - (4,411\ 75 \times H_f)$

where H_f is the moisture content of the flour.

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

9.3 Kneading

Place 250 g of flour, weighed (5.3) to within 0,5 g, in the kneading machine (5.7.1). Secure the lid with the locking device.

At the same time, switch on the motor, start the timer on the MA 82 models and use a burette (5.8) to deliver the appropriate quantity of sodium chloride solution (4.1) through the hole in the cover.

If the moisture content of the flour is less than 10,5 %, use the burette (5.8) to add a quantity of sodium chloride solution corresponding to a moisture content of 12 %, i.e. 138,2 ml. With a pipette (5.13), add a quantity of sodium chloride solution equal to the difference between the value given in Table 2 and the 138,2 ml already in the machine.

Allow the dough to form for 1 min, then switch off the motor, open the cover and, using the plastic spatula provided, reincorporate any flour and dough adhering to the *F*-register (see Figure 6) and to the corners of the kneading machine. This operation should take less than 1 min. This operation can be performed in two parts, allowing the kneading machine to rotate about 10 times between the first and second operations.

Close the cover, then restart the motor and knead for 6 min. During this time, oil the accessories required for extrusion.

Stop kneading after a total of 8 min (corresponding to the sum of dough formation and reincorporation times), then extrude the dough test pieces (the NG has an automatic stop).

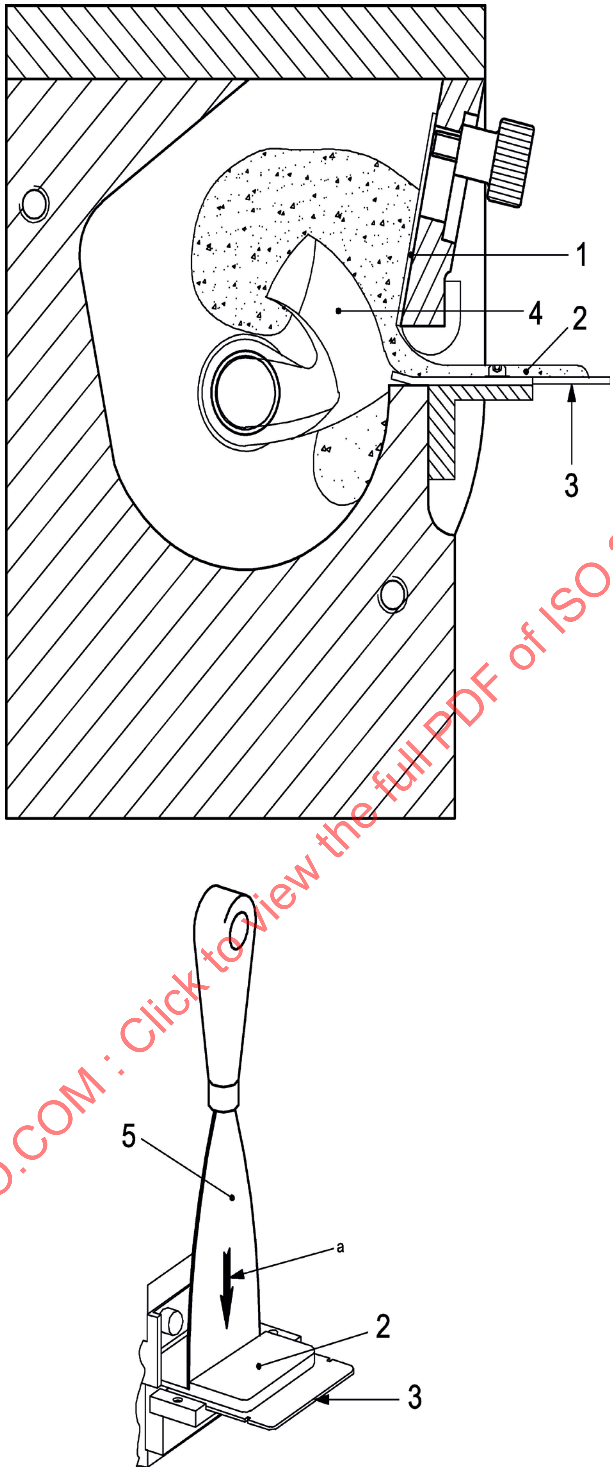
9.4 Preparation of dough test pieces

Reverse the direction of rotation of the kneader blade. Open the extrusion aperture by raising the *F*-register and place a few drops of oil (4.2) on the previously installed receiving plate. Remove the first centimetre of dough using the knife/spatula in a clean, downward movement, close to the guide (see Figure 6).

When the strip of dough is level with the notches on the extrusion plate, quickly cut the dough with the knife/spatula. Slide the piece of dough onto the previously oiled stainless steel plate on the sheeting table (first dough piece; see Figure 6).

Successively extrude five dough pieces without stopping the motor, replacing the previously oiled receiving plate each time. Arrange the first four dough pieces on the sheeting table so that their direction of extrusion corresponds to its major axis [Figure 7a)]. Leave the fifth dough piece on the extrusion plate. Stop the motor.

NOTE Experienced operators are able to sheet, cut, and transfer each dough piece to the rest chamber in the same amount of time it takes to extrude the next dough piece.



Key

1 F-register
2 dough
3 receiving plate
4 kneader blade
5 knife/spatula
a Direction of cutting the extruded dough.

Figure 6 — Kneading machine

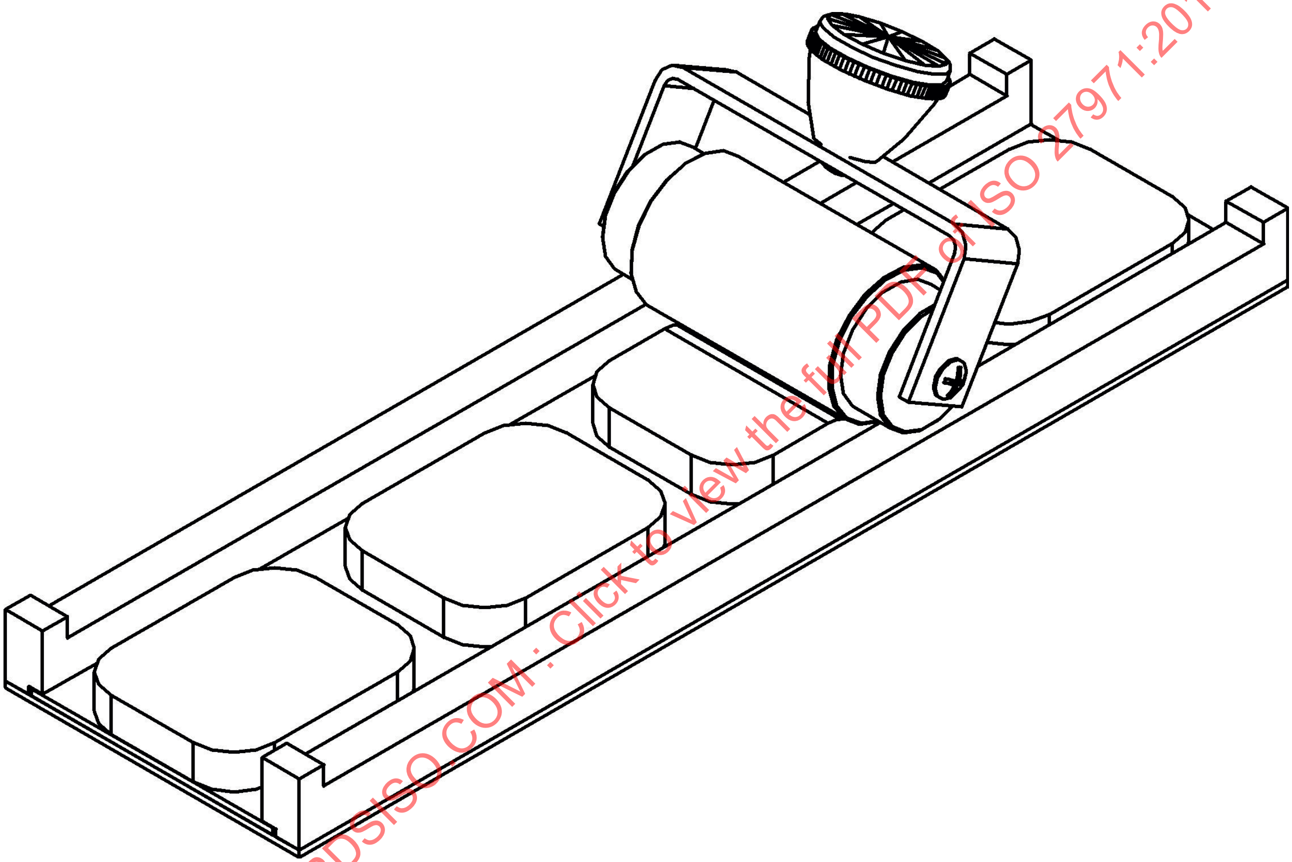
Sheet the four dough pieces using the previously oiled steel roller; run the roller backwards and forwards along the rails 12 times in succession, six times in each direction [see Figure 7a)].

Using the cutter, cut a test piece from each strip of dough in one clean movement [see Figure 7b)]. Remove any surplus dough.

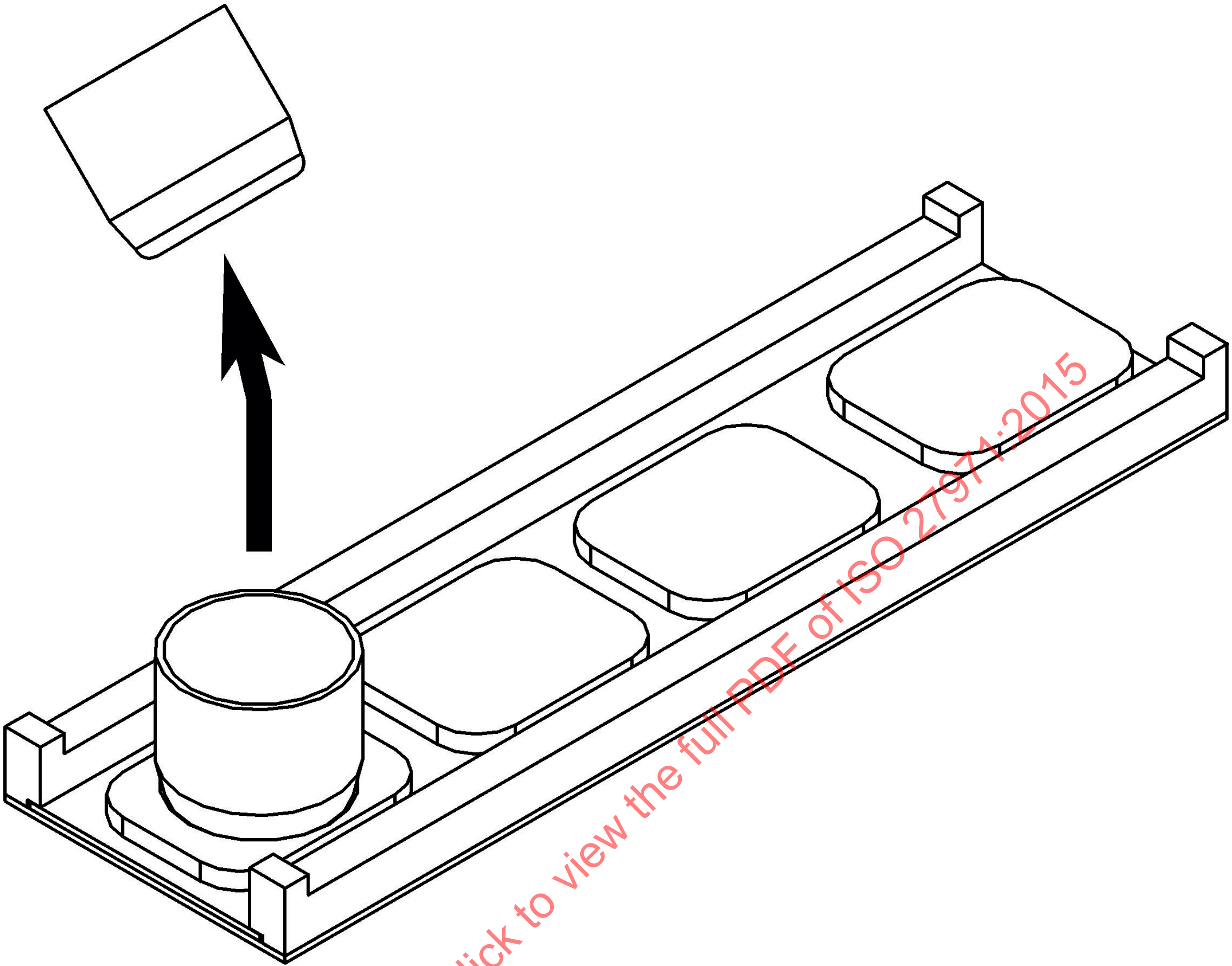
Hold the cutter containing the dough test piece above the previously oiled resting plate to which it is to be transferred. If the dough sticks to the sides of the cutter, free it by tapping the work surface with the palm of the hand (do not touch with fingers). If the test piece remains on the stainless steel plate on the sheeting table, raise it gently with the spatula [see Figure 7c)] and slide the resting plate under it.

Immediately place each resting plate containing a dough piece into the thermostatically controlled compartment of the alveograph, heated to 25 °C. Proceed by order of extrusion, carefully noting the location of the first test piece.

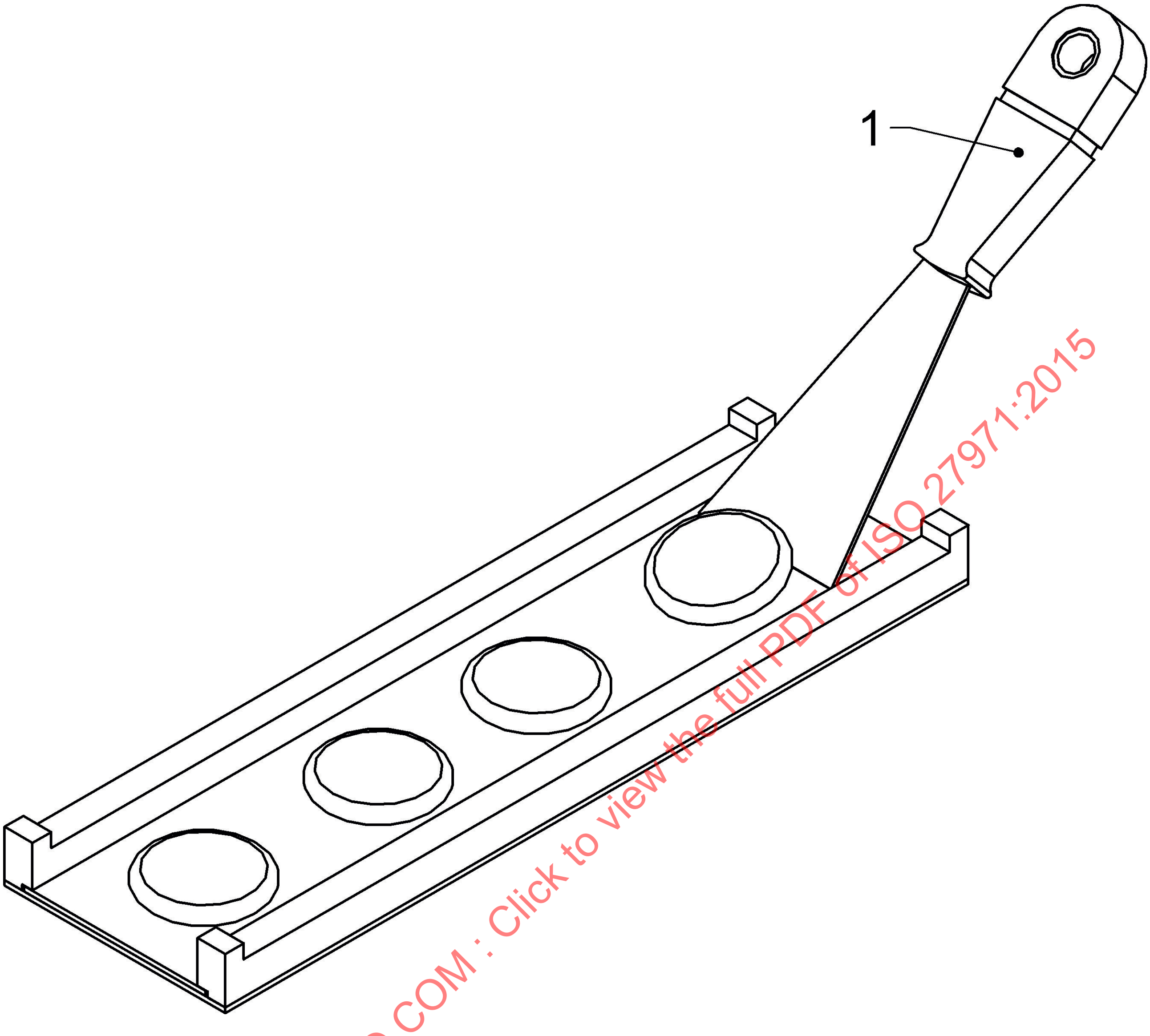
Repeat the operations described above with the fifth dough piece.



a) Sheeting dough pieces



b) Cutting dough pieces



c) Transfer dough pieces

Key

1 spatula

Figure 7 — Preparation of dough test pieces

9.5 Alveograph test

9.5.1 Initial preparation

If a hydraulic manometer is used, distance the recording pen from the drum and place a recording chart on the drum. Fill the pen with ink. Turn the cylinder until it comes into contact with its stop. Bring the pen into contact with the cylinder and turn the cylinder so that it draws the zero line. Move the pen aside again to move the drum against the stop in its starting position.

Perform the test 28 min after kneading begins. Check that the piston is in the raised position. Proceed in the order of extrusion of the test pieces.

9.5.2 First operation: Adjusting the dough test piece

Raise the handle to the vertical position on the NG model [Figure 8a)].

Raise the top plate by unscrewing it two turns to bring it level with the three guide studs [Figure 8a)].

Remove the ring and the plug [Figure 8a)].

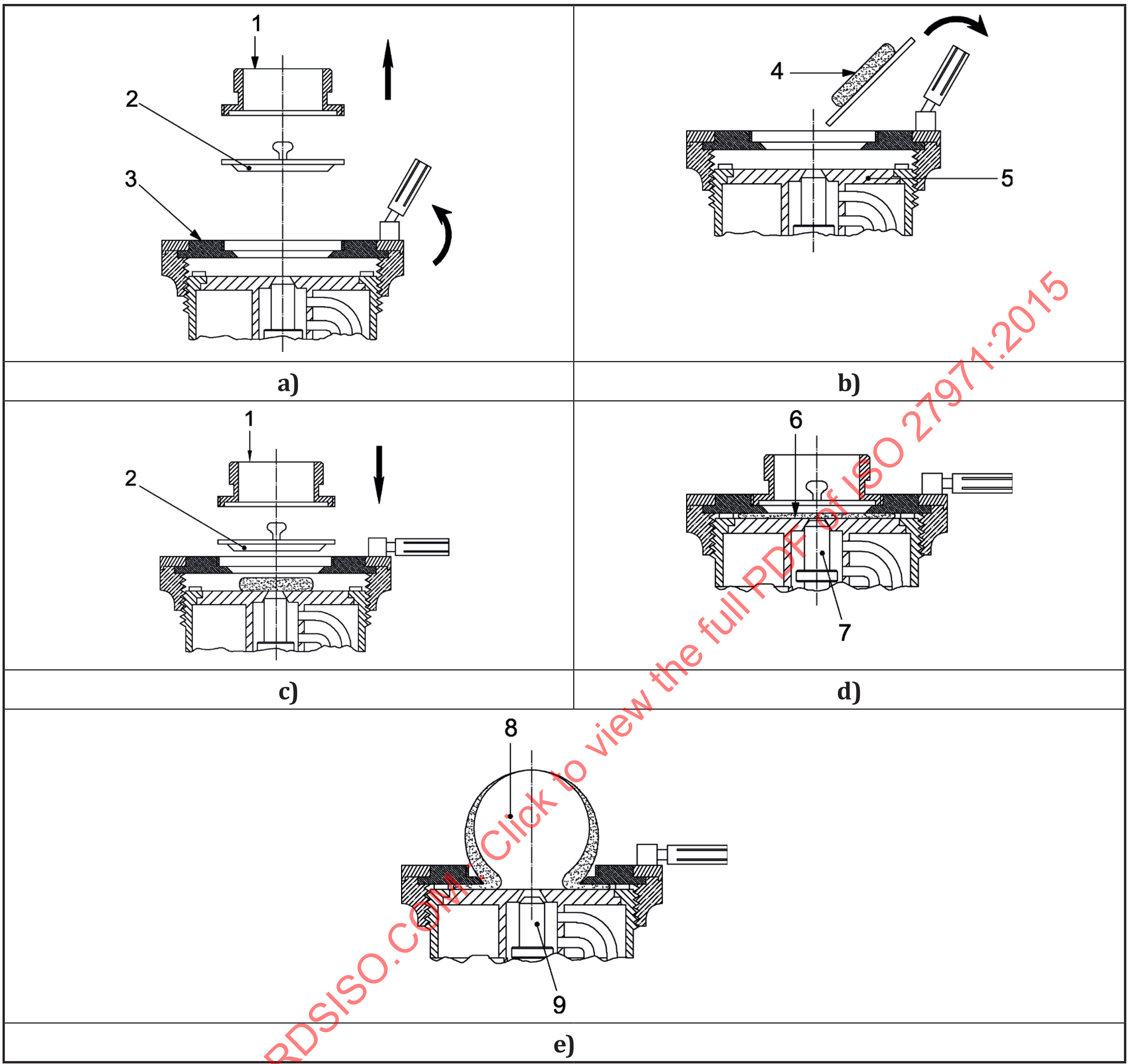
Oil the bottom plate and the inner surface of the plug.

Slide the dough test piece onto the centre of the bottom plate [Figure 8b)].

Replace the plug and the ring [Figure 8c)].

Calibrate the test piece by slowly tightening the top plate by two turns in approximately 20 s [Figure 8d)].

Remove the ring and plug to free the dough test piece.



Key

1 ring
2 plug
3 top plate
4 dough test piece
5 bottom plate
6 calibrated dough test piece
7 piston in raised position
8 inflated dough test piece
9 piston in low position

Figure 8 — Alveograph test

9.5.3 Second operation: biaxial extension

On the NG model, press the ON/OFF button to start the test.

On the MA 95 model, set handle A to position 2 [see Figure 1c)] to release the test piece automatically, inflate the dough bubble and start the recording drum.

On other models, the dough piece is released by setting the handle to an intermediate position. Turn the tap to the horizontal position, squeeze the rubber pear-shaped bulb between the thumb and the index finger and without releasing the pressure, turn the tap to the vertical position. Set handle A to position 3 to begin inflation.

Watch as the bubble inflates, in order to determine the exact moment of rupture. Immediately stop measuring by turning handle A to position 1, or by pressing the ON/OFF button on the NG models.

Where a recording drum is used, draw the five curves on the same sheet taking care to return the drum to its initial position before testing each dough piece.

Repeat the operations specified in 9.5.1 to 9.5.3 on the four remaining dough test pieces.

9.6 Expression of alveograph test results

9.6.1 General

The results are measured or calculated from the five curves obtained. However, if one (and only one) of the curves deviates greatly from the other four, it should not be taken into account in the expression of results (see Figure 9).

9.6.2 Maximum pressure parameter, *P*

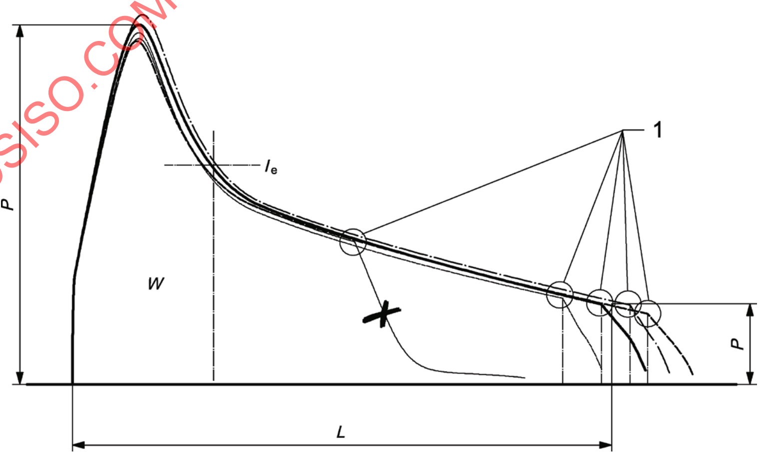
P corresponds to the maximum pressure within the bubble, which is related to the deformation resistance (stiffness). The value of *P* equals the mean of the maximum ordinates, in millimetres, multiplied by a factor, $K = 1,1$.

Record *P* to the nearest integer.

9.6.3 Mean abscissa at rupture, *L*

The mean of the abscissa values at rupture of the curves represents the length, *L*. These abscissa values are measured, in millimetres, for each curve along the base line, from the origin of the curves to the point corresponding vertically to the start of the pressure drop.

Record *L* to the nearest integer.



Key

1 rupture points

I_e elasticity index, $(P_{200}/P) \times 100$, %

L mean abscissa at rupture points

P maximum pressure parameter (mean of maximumordinates times 1,1)

W deformation work

Figure 9 — Alveograph curve

9.6.4 Swelling index, *G*

The mean of the abscissa values at rupture, *L*, converted to the swelling index, *G*, represents the extensibility of the dough. This value is the square root of the volume of air, in millilitres, required to inflate the bubble until it ruptures. It is calculated using Formula (4):

$$G = 2{,}226\sqrt{L} \tag{4}$$

Annex D gives a conversion table from *L* to *G*.

Record *G* to the nearest first decimal place.

9.6.5 Elasticity index

The elasticity index, I_e, expressed as a percentage, is calculated using Formula (5):

$$I_e = \left(\frac{P_{200}}{P}\right) \times 100 \tag{5}$$

where P_{200} is the pressure inside the bubble when a volume of 200 ml of air has been injected into the test piece. P_{200} corresponds on the alveogram to the height of the mean curve at L = 40 mm, multiplied by the coefficient 1,1

Record I_e to the first decimal place.

9.6.6 Curve configuration ratio, *P*/*L*

The term “curve configuration” is conventional.

Record *P*/*L* to the nearest second decimal place.

9.6.7 Deformation work, *W*

W represents the baking strength of the flour and the work of deformation of 1 g of dough obtained by the method described. It is expressed in units of 10^{-4} J. *W* is calculated from the alveogram parameters and various experimental factors, using Formula (6):

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

where *S* is the area under the mean curve.

The coefficient 6,54 is valid for:

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

b) a constant air flow rate of 96 l/h;

c) a hydraulic manometer with the coefficient, *K* = 1,1.

Record *W* to the nearest integer.

10 Precision

10.1 Interlaboratory tests

a) **Commercial flour:**

The repeatability and reproducibility limits of the method used for commercial flour were initially established within the context of an interlaboratory test, details of which are given in Annex E.

In order to extend the concentration range of the various parameters for use more appropriate to actual practice, the results obtained from the proficiency tests organized by the Bureau Interprofessionnel des Etudes Analytiques/Interprofessional Bureau for Analytical Studies (BIPEA) were applied to obtain new reproducibility limits, as given in Annex E.

b) **Flour obtained from laboratory milling:**

The repeatability and reproducibility limits of the method used for flour obtained from laboratory milling were established by two interlaboratory tests performed in 2001 and 2004 according to ISO 5725-2, ISO 5725-3, and ISO 5725-6, details of which are given in Annex F.

The values obtained from each analysis apply to the concentration ranges and to the matrices tested.

10.2 Repeatability limits

Repeatability is the value below which there is a 95 % probability that the absolute value of the difference between two test results obtained under repeatability conditions will lie.

The repeatability, r, limits are obtained by the equations below. To make them easier to use, practical application tables are given in Annexes E and F.

10.2.1 Commercial flour: limits established by the interlaboratory test

For W: $r = (0{,}0541\ W - 1{,}5715) \times 2{,}77$

For P: $r = (0{,}0173\ P + 0{,}3107) \times 2{,}77$

For L: $r = (0{,}1449\ L - 7{,}083) \times 2{,}77$

For G: $r = (0{,}1218\ G - 1{,}8617) \times 2{,}77$

For P/L: $r = (0{,}125 P/L - 0{,}06) \times 2{,}77$

10.2.2 Flour obtained from laboratory milling

For W: $r = (0{,}0344\ W + 3{,}9038) \times 2{,}77$

For P: $r = (0{,}0268\ P + 0{,}535) \times 2{,}77$

For L: $r = (0{,}049\ L + 2{,}3471) \times 2{,}77$

For G: $r = 0{,}81 \times 2{,}77 = 2{,}2$

For P/L: $r = (0{,}1215\ P/L - 0{,}0154) \times 2{,}77$

For I_e : $r = 0{,}6 \times 2{,}77 = 1{,}6$

For the extraction rate: $r = 0{,}8 \times 2{,}77 = 2{,}3$

10.3 Reproducibility limits

Reproducibility is the value below which there is a 95 % probability that the absolute value of the difference between two test results obtained under reproducibility conditions will lie.

The reproducibility, R, limits are obtained by the equations below. To make them easier to use, practical application tables are given in Annexes E and F.

10.3.1 Commercial flour: Limits established by the proficiency tests

For W : $R = (0{,}059\ \mathrm{W} + 2{,}05) \times 2{,}77$

For P : R = (0,045 P + 0,15) × 2,77

For L : R = (0,06 L + 1,81) × 2,77

For G : R = 0,8 × 2,77 = 2,5

For P/L : R = (0,1214 P/L - 0,0184) × 2,77

For I_e : R = 2 × 2,77 = 5,5

10.3.2 Flour obtained from laboratory milling

For W: R = (0,0534 W + 4,1951) × 2,77

For P: R = (0,0637 P + 1,5799) × 2,77

For L: R = (0,0998 L + 1,3311) × 2,77

For G: R = 1,25 × 2,77 = 3,5

For P/L: R = (0,2107 P/L - 0,0154) × 2,77

For I_e : R = 2,7 × 2,77 = 7,5

For the extraction rate: R = 3,8 × 2,77 = 10,5

10.4 Uncertainty

Uncertainty, u,[7] is a parameter characterizing the dispersion of values that can reasonably be attributed to the result. This uncertainty is given by a statistical distribution of the results from the interlaboratory test and is characterized by the experimental standard deviation.

For each parameter, uncertainty is equal to more or less twice the reproducibility standard deviation featuring in this International Standard.

11 Test report

The test report shall specify the following:

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

b) the test method used, with reference to this International Standard, i.e. ISO 27971;

c) when laboratory milling is included in the test: all information necessary for the complete identification of the mill used;

d) the alveograph parameters and the units used to record them;

e) all operating details not specified in this International Standard, or regarded as optional, together with details of any incidents noted during the milling process and alveograph test that might have influenced the test results.

Annex A
(informative)

Characteristics of the Chopin-Dubois CD1 mill

A.1 Breaking

Three stacked hardened-steel fluted rollers with oblique teeth (two passages).

Non-adjustable clearance:	First passage	1,00 mm
	Second passage	0,10 mm
Non-adjustable roller speeds:	Top roller	200 min^{-1}
	Intermediate roller	450 min^{-1}
	Bottom roller	200 min^{-1}

A.2 Reduction

Two smooth cast-iron rollers in contact (one run), cleaned by two scrapers. The pressure can be adjusted by adding or removing additional weights or by means of the spring pressure on the roller load.

Roller speed:	Top roller	325 min^{-1}
	Bottom roller	325 min^{-1}

A.3 Sieve material

A.3.1 Post-break

A.3.1.1 Stainless steel flour sieve, with wire diameter 110 µm; mesh aperture 160 µm; and sieving area, 38 %.

A.3.1.2 Galvanized steel semolina sieve, with wire diameter 315 µm; mesh aperture 800 µm; and sieving area, 51 %.

A.3.2 Post-reduction

As for A.3.1.1.

A.4 Milling

Break time: adjust the feed rate to allow 800 g of wheat to pass through the mill in (5 ± 1) min.

Reduction time: adjust the feed rate to allow the quantity of semolina obtained from the break system to pass through the mill in (5 ± 1) min.

Sieving time: continue sieving for (180 ± 30) s after the break system has finished. Do the same after the reduction process (es).

A.5 Break performance indicator

Irrespective of the type of wheat milled, the percentage of bran obtained from the break system shall be between 17 % and 23 % of the wheat mass used. A percentage outside this range indicates an incorrect setting or inadequate device maintenance.

A.6 Reduction performance indicator

Irrespective of the type of wheat milled, the percentage of middlings obtained from the reduction process shall be between 9 % and 17 % of the wheat mass used. A percentage outside this range indicates an incorrect setting or inadequate device maintenance.

A.7 Maintenance operations

Check the sieve screens regularly. The frequency recommended by the manufacturer is once per month. Replace sieves immediately if they are damaged, for example if they become detached or if any holes appear (do not patch them up). If they become obstructed, it is best to clean them with compressed air. Never wet the sieves.

Remove any metal particles from the safety magnet.

Use a shim to measure the amount of wear on the beater blades every 6 months. The gap between the blade and the casing shall be less than 2 mm. Otherwise, replace the beater.

Check the amount of wear on the scrapers every year.

Replace the foam O-rings at least once a year or as soon as they become detached or begin to deteriorate.

It is recommended that every two years, a qualified engineer check the mechanical condition of the mill, and where necessary take remedial action, for:

a) the amount of wear on the bearings and scrapers;

b) the condition of the sieves;

c) the slope of the blades on the break and reduction sides;

d) the condition of the roll surface;

e) the tension of the reduction compression spring;

f) the condition of the wheat and semolina feed systems.

Annex B
(normative)

Quantity of water to be added to wheat for conditioning

The mass of water, M_e, in grams, to be added to wheat for the purposes of moisture conditioning is calculated according to Formula (B.1):

$$M_{e=}\left[M_b \times \left(H_s - H_b\right)\right] / \left(100 - H_s\right) \tag{B.1}$$

where

M_b is the wheat mass, in grams, to be conditioned;

H_b is the moisture content, as a percentage, of the wheat prior to conditioning;

H_s is the required moisture content, as a percentage, of the wheat after conditioning.

Express M_e to the nearest 0,5 g. The value of M_e is numerically equivalent to the volume, V_e, in millilitres, of water required.

Table B.1 — Moisture conditioning to 16 % mass fraction for 800 g of wheat

Wheat moisture content (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml
9,0	67,0	11,0	48,0	13,0	29,0	15,0	9,5
9,1	66,0	11,1	47,0	13,1	28,0		
9,2	65,0	11,2	46,0	13,2	27,0	If the moisture content of the wheat exceeds 15 %, dry the wheat before remoistening (see 7.4.4).	
9,3	64,0	11,3	45,0	13,3	26,0		
9,4	63,0	11,4	44,0	13,4	25,0		
9,5	62,0	11,5	43,0	13,5	24,0		
9,6	61,0	11,6	42,0	13,6	23,0		
9,7	60,0	11,7	41,0	13,7	22,0		
9,8	59,0	11,8	40,0	13,8	21,0		
9,9	58,0	11,9	39,0	13,9	20,0	If the moisture content of the wheat is less than 13 %, add the water in two stages (see 7.4.3).	
10,0	57,0	12,0	38,0	14,0	19,0		
10,1	56,0	12,1	37,0	14,1	18,0		
10,2	55,0	12,2	36,0	14,2	17,0		
10,3	54,5	12,3	35,0	14,3	16,0		
10,4	53,5	12,4	34,5	14,4	15,0		

Table B.1 *(continued)*

Wheat moisture content (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml	**Wheat moisture content** (before conditioning) H_b %	**Water mass or volume** M_e or V_e g or ml
10,5	52,5	12,5	33,5	14,5	14,5		
10,6	51,5	12,6	32,5	14,6	13,5		
10,7	50,5	12,7	31,5	14,7	12,5		
10,8	49,5	12,8	30,5	14,8	11,5		
10,9	47,0	12,9	29,5	14,9	10,5		

Annex C
(informative)

Sample milling sheet

Users of this International Standard may copy this sheet for practical use.

		WHEAT SAMPLE REFERENCE:		
Initial moisture content (%) of cleaned wheat	H_{b0}			
→ if H_{b0} > 15 %, pre-dry (see 7.4.4)		start of pre-drying: date: time:		
		end of pre-drying: date: time:		
Initial moisture content (%) of cleaned wheat after pre-drying, if any (if no pre-drying, $H_{b0} = H_b$)	H_b			
Quantity of water to be added to condition to 16 % (see Annex B) (g, ml)	M_e, V_e			
A. If H_b < 13 %, add the water in two stages (see 7.4.3)		1. add M_1 g of water; M_1 = g; date: time:		
		2. add M_2 g of water; M_2 = g; date: time:		
		(where $M_1 + M_2 = M_e$)		
B. If 15 % ≐ H_b ≐ 13 %, add the water in one go (see 7.4.2).		add M_e g of water; M_e = g: date: time:		
Mass of clean wheat milled (g)	M_b			
Mass of clean wheat milled expressed as dry mass (g)	MS_b	$= M_b \times (100 - H_b) / 100 =$		
Total mass milled (g) Mb	T_1	$= (M_b + M_e) =$		
Test mill identification:				
Start of milling:		Date: time:		
Flour mass after break system (g)	M_{br}			
Semolina mass after break system (g)	M_{sem}			
Reduction flour mass (g)	M_{conv}			
Number of reductions	N			
Total flour mass (g)	M_f	$= (M_{br} + M_{conv}) =$		
Bran mass (g)	M_s		i.e. S = %	
Middlings mass (g)	M_r		i.e. R = %	
Total mass of milled products (g)	M_{tot}	$= (M_f + M_s + M_r) =$		
Moisture content of the flour (%)	H_f			
Total flour mass expressed as dry matter (g)	MS_f	$= M_f \times (100 - H_f) / 100 =$		
Extraction rate, dry matter/dry matter (%)	ER	$= (MS_f / MS_b) \times 100 =$		
Gross milling ratio (%)	BM	$= (T_2 / T_1) \times 100 =$		
Ash yield of the flour (% dry matter, see ISO 2171[2])			(if determined)	
Damaged starch content of the flour			(if determined)	
Breaking time (min)				
Reduction time (min)				

Annex D
(informative)

Conversion table from *L* to *G*

Table D.1 — Conversion of the length, *L*, to swelling, *G*, using Formula (4): $G = 2{,}226\sqrt{L}$

Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml
13,0	8,0	63,0	17,7	113,0	23,7	163,0	28,4	213,0	32,5
14,0	8,3	64,0	17,8	114,0	23,8	164,0	28,5	214,0	32,6
15,0	8,6	65,0	17,9	115,0	23,9	165,0	28,6	215,0	32,6
16,0	8,9	66,0	18,1	116,0	24,0	166,0	28,7	216,0	32,7
17,0	9,2	67,0	18,2	117,0	24,1	167,0	28,8	217,0	32,8
18,0	9,4	68,0	18,4	118,0	24,2	168,0	28,9	218,0	32,9
19,0	9,7	69,0	18,5	119,0	24,3	169,0	28,9	219,0	32,9
20,0	10,0	70,0	18,6	120,0	24,4	170,0	29,0	220,0	33,0
21,0	10,2	71,0	18,8	121,0	24,5	171,0	29,1	221,0	33,1
22,0	10,4	72,0	18,9	122,0	24,6	172,0	29,2	222,0	33,2
23,0	10,7	73,0	19,0	123,0	24,7	173,0	29,3	223,0	33,2
24,0	10,9	74,0	19,1	124,0	24,8	174,0	29,4	224,0	33,3
25,0	11,1	75,0	19,3	125,0	24,9	175,0	29,4	225,0	33,4
26,0	11,4	76,0	19,4	126,0	25,0	176,0	29,5	226,0	33,5
27,0	11,6	77,0	19,5	127,0	25,1	177,0	29,6	227,0	33,5
28,0	11,8	78,0	19,7	128,0	25,2	178,0	29,7	228,0	33,6
29,0	12,0	79,0	19,8	129,0	25,3	179,0	29,8	229,0	33,7
30,0	12,2	80,0	19,9	130,0	25,4	180,0	29,9	230,0	33,8
31,0	12,4	81,0	20,0	131,0	25,5	181,0	29,9	231,0	33,8
32,0	12,6	82,0	20,2	132,0	25,6	182,0	30,0	232,0	33,9
33,0	12,8	83,0	20,3	133,0	25,7	183,0	30,1	233,0	34,0
34,0	13,0	84,0	20,4	134,0	25,8	184,0	30,2	234,0	34,1
35,0	13,2	85,0	20,5	135,0	25,9	185,0	30,3	235,0	34,1
36,0	13,4	86,0	20,6	136,0	26,0	186,0	30,4	236,0	34,2
37,0	13,5	87,0	20,8	137,0	26,1	187,0	30,4	237,0	34,3
38,0	13,7	88,0	20,9	138,0	26,1	188,0	30,5	238,0	34,3
39,0	13,9	89,0	21,0	139,0	26,2	189,0	30,6	239,0	34,4
40,0	14,1	90,0	21,1	140,0	26,3	190,0	30,7	240,0	34,5
41,0	14,3	91,0	21,2	141,0	26,4	191,0	30,8	241,0	34,6
42,0	14,4	92,0	21,4	142,0	26,5	192,0	30,8	242,0	34,6
43,0	14,6	93,0	21,5	143,0	26,6	193,0	30,9	243,0	34,7
44,0	14,8	94,0	21,6	144,0	26,7	194,0	31,0	244,0	34,8

Table D.1 *(continued)*

Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml	Length *L* mm	Swelling *G* ml
45,0	14,9	95,0	21,7	145,0	26,8	195,0	31,1	245,0	34,8
46,0	15,1	96,0	21,8	146,0	26,9	196,0	31,2	246,0	34,9
47,0	15,3	97,0	21,9	147,0	27,0	197,0	31,2	247,0	35,0
48,0	15,4	98,0	22,0	148,0	27,1	198,0	31,3	248,0	35,1
49,0	15,6	99,0	22,1	149,0	27,2	199,0	31,4	249,0	35,1
50,0	15,7	100,0	22,3	150,0	27,3	200,0	31,5	250,0	35,2
51,0	15,9	101,0	22,4	151,0	27,4	201,0	31,6	251,0	35,3
52,0	16,1	102,0	22,5	152,0	27,4	202,0	31,6	252,0	35,3
53,0	16,2	103,0	22,6	153,0	27,5	203,0	31,7	253,0	35,4
54,0	16,4	104,0	22,7	154,0	27,6	204,0	31,8	254,0	35,5
55,0	16,5	105,0	22,8	155,0	27,7	205,0	31,9	255,0	35,5
56,0	16,7	106,0	22,9	156,0	27,8	206,0	31,9	256,0	35,6
57,0	16,8	107,0	23,0	157,0	27,9	207,0	32,0	257,0	35,7
58,0	17,0	108,0	23,1	158,0	28,0	208,0	32,1	258,0	35,8
59,0	17,1	109,0	23,2	159,0	28,1	209,0	32,2	259,0	35,8
60,0	17,2	110,0	23,3	160,0	28,2	210,0	32,3	260,0	35,9
61,0	17,4	111,0	23,5	161,0	28,2	211,0	32,3	261,0	36,0
62,0	17,5	112,0	23,6	162,0	28,3	212,0	32,4	262,0	36,0

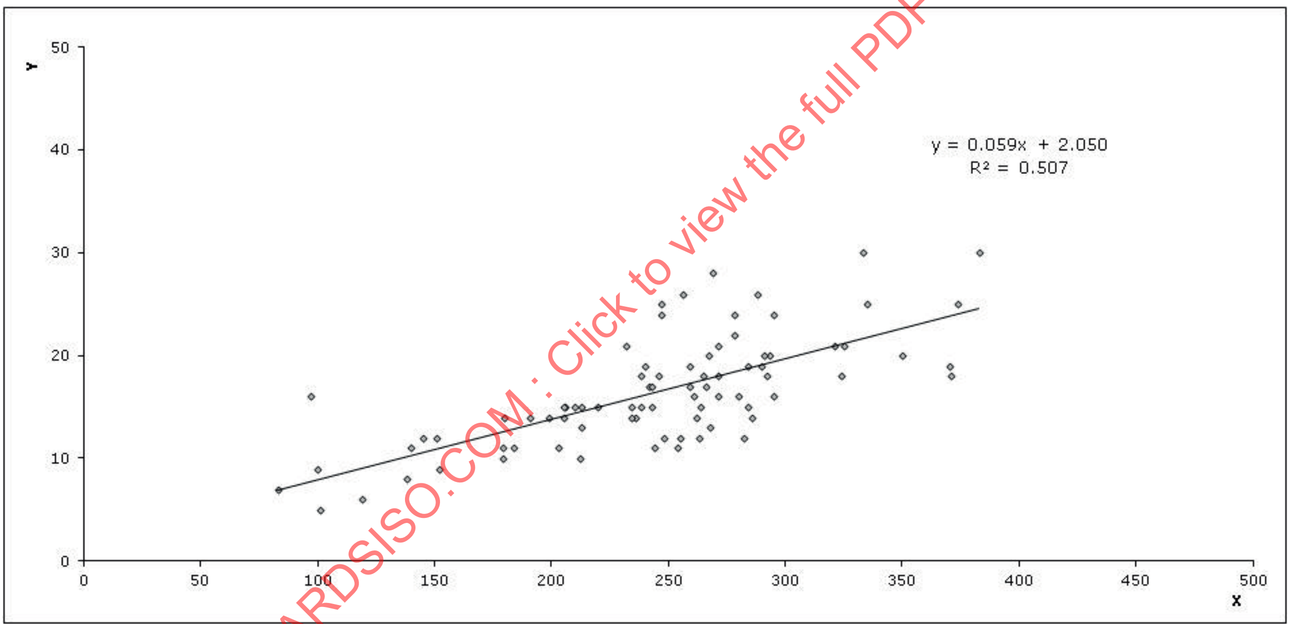
Annex E
(informative)

Interlaboratory and proficiency test data for commercial flours

The repeatability and reproducibility limits of the method used for commercial flour were initially established within the context of an interlaboratory test in which six laboratories participated. The test was performed on three samples of flour and repeated four times on each sample.

In order to extend the concentration range of the various parameters for use more appropriate to actual practice, the results obtained from the proficiency tests organized by the Bureau Interprofessionnel des Etudes Analytiques/Interprofessional Bureau for Analytical Studies (BIPEA) were applied.

14 to 29 laboratories, depending on the campaign, participated in the tests between 2005 and 2013, and new reproducibility limits were obtained from 80 results. Repeatability limits cannot be extracted from proficiency tests because, as in the current application of the alveograph test, the number of repetitions is generally one.



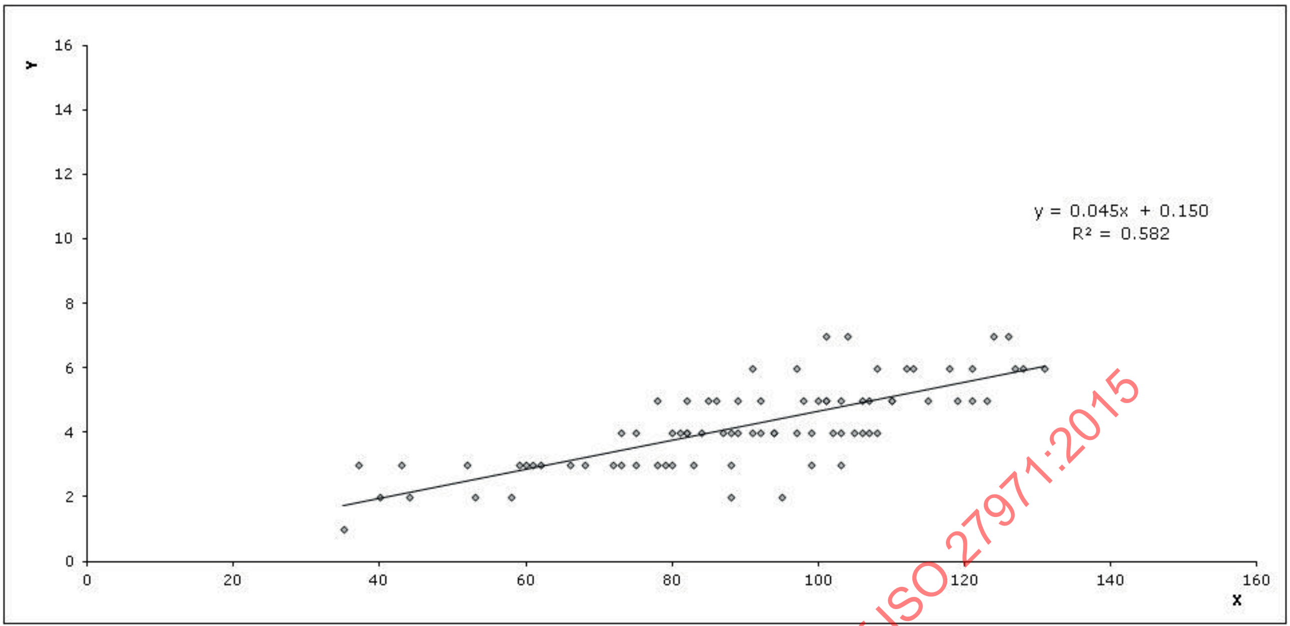
Key

W mean of the control laboratories' *W* values

s_R $y = 0{,}059\,x + 2{,}05$; $R^2 = 0{,}507$ (correlation coefficient)

Figure E.1 — Relationship between reproducibility standard deviation and mean values of *W* (data from the proficiency tests)

Figure E.1 shows that the standard deviations of reproducibility are dependent on the mean values of *W*.



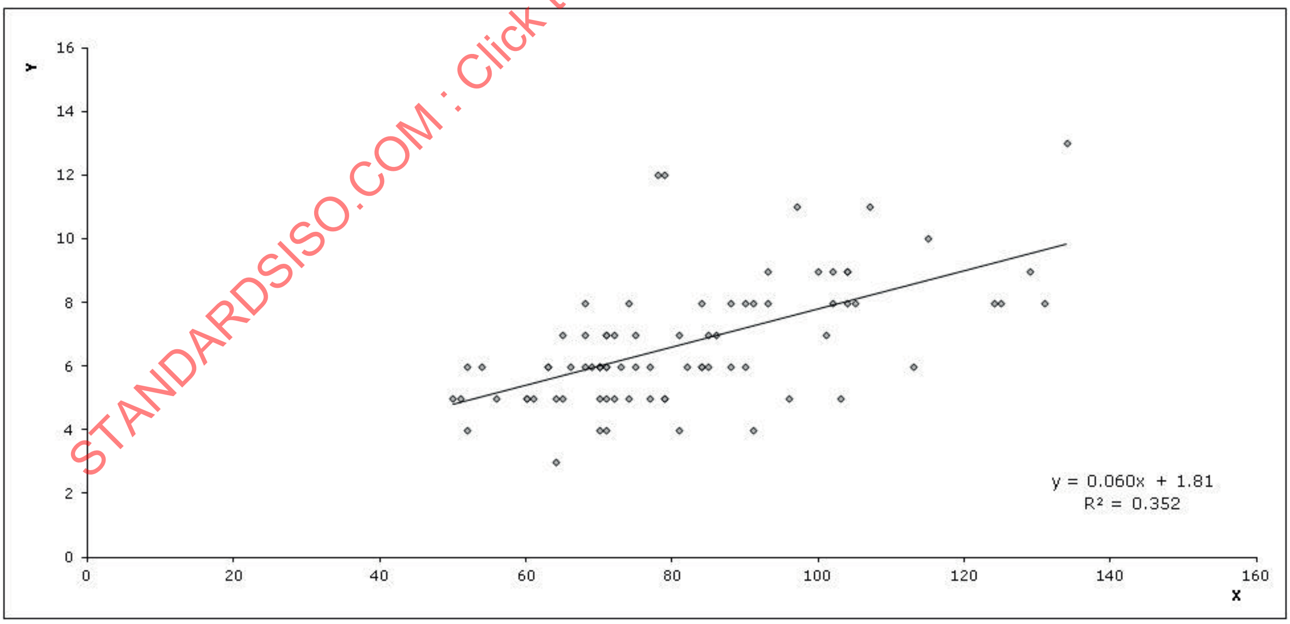
Key

P mean of *P* of the control laboratories

s_R y = 0,045 x + 0,15 ; R^2 = 0,582 (correlation coefficient)

Figure E.2 — Relationship between reproducibility standard deviation and mean values of *P* (data from the proficiency tests)

Figure E.2 shows that the standard deviations of reproducibility are dependent on the mean values of *P*.



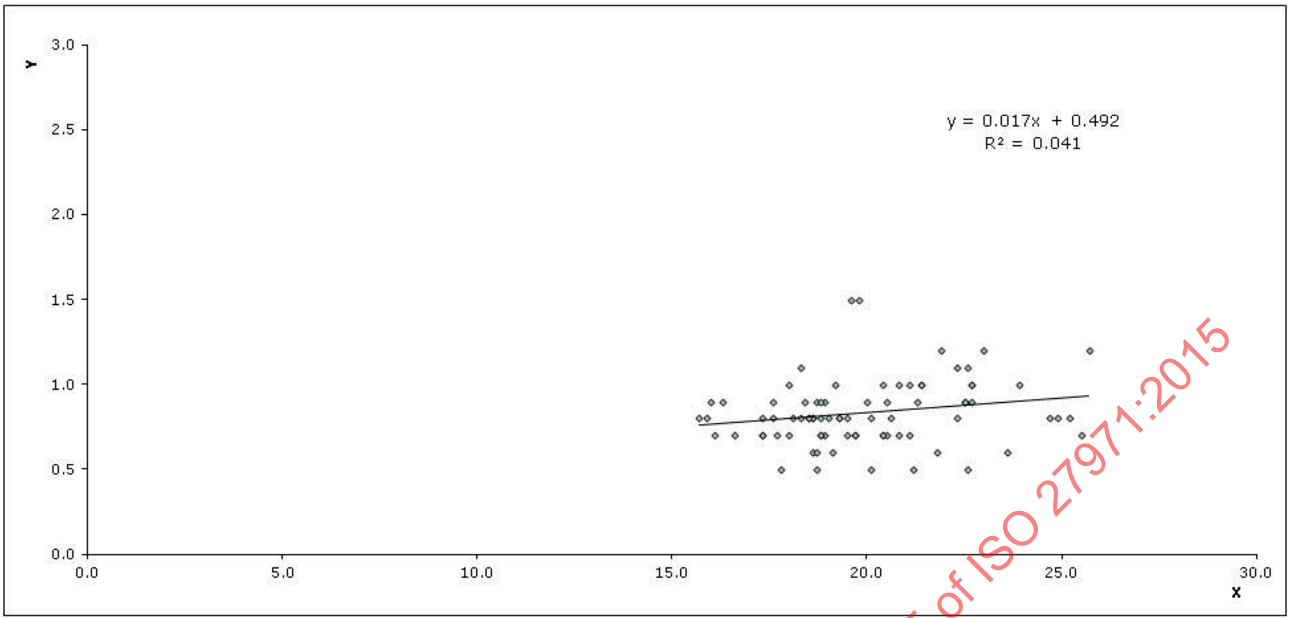
Key

L mean of the control laboratories' *L* values

s_R y = 0,06 x + 1,81 ; R^2 = 0,352 (correlation coefficient)

Figure E.3 — Relationship between reproducibility standard deviation and mean values of *L* (data from the proficiency tests)

Figure E.3 shows that the standard deviations of reproducibility are dependent on the mean values of *L*.



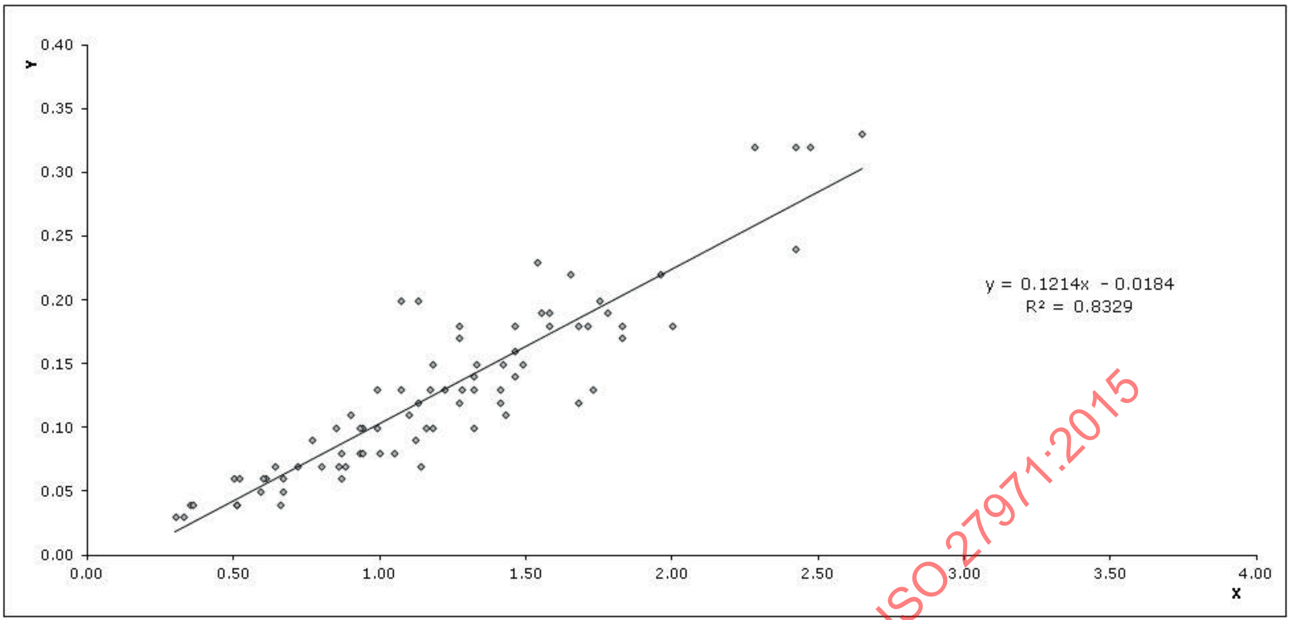
Key

G mean of the control laboratories' *G* values

s_R y = 0,017 x + 0,492 ; R^2 = 0,041 (correlation coefficient)

Figure E.4 — Relationship between reproducibility standard deviation and mean values of *G* (data from the proficiency tests)

Figure E.4 shows that the standard deviations of reproducibility are constant irrespective of the mean value of *G*.



Key

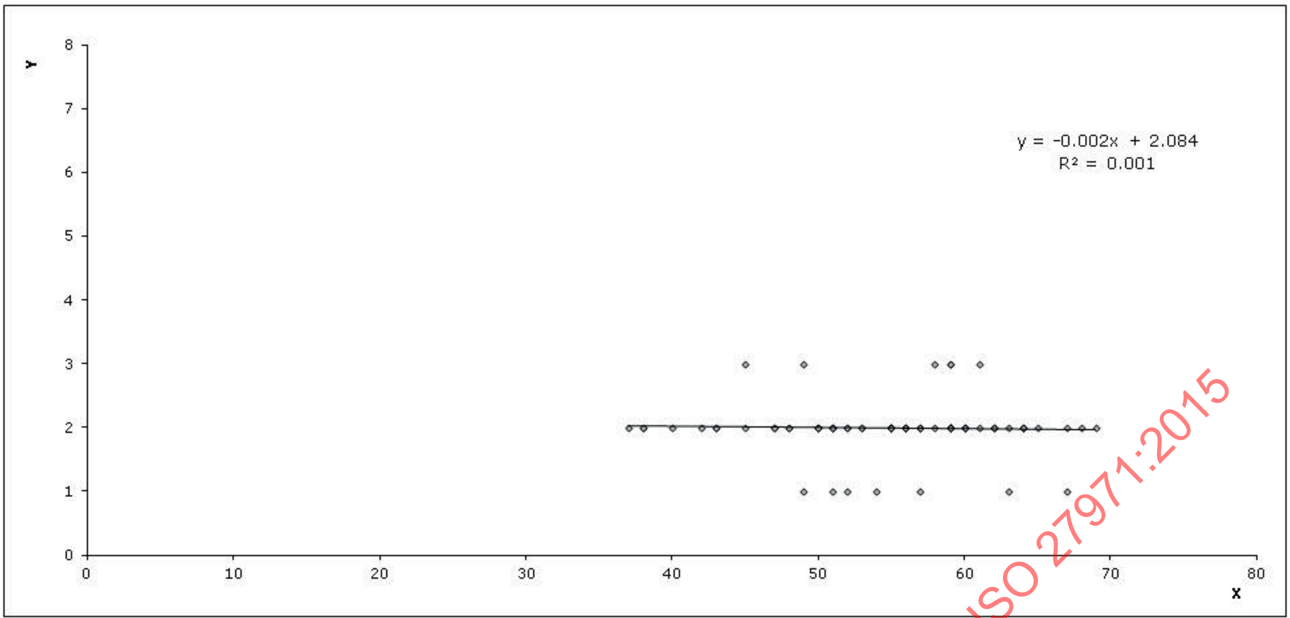
P/L mean of the control laboratories' *P/L* values

s_R standard deviation of reproducibility

s_R y = 0,121 x – 0,018 ; R^2 = 0,833 (correlation coefficient)

Figure E.5 — Relationship between reproducibility standard deviation and mean values of *P/L* (data from the proficiency tests)

Figure E.5 shows that the standard deviations of reproducibility are dependent on the mean values of *P/L*.



Key

I_e mean of the control laboratories' Ie values

s_R standard deviation of reproducibility

s_R y = - 0,002 x + 2,084 ; R^2 = 0,001 (correlation coefficient)

Figure E.6 — Relationship between reproducibility standard deviation and mean values of I_e (data from the proficiency tests)

Figure E.6 shows that the standard deviations of reproducibility are constant irrespective of the mean value of I_e.

Table E.1 — Summary of reproducibility equations for commercial flour (data from the proficiency tests)

Parameter	Validity range of the interlaboratory test	s_R
W	83 to 383	0,06 W + 2
P	35 to 131	0,05 P + 0,15
L	50 to 134	0,06 L + 2
G	15,7 to 25,7	0,8
P/L	0,30 to 2,65	0,12 P/L – 0,02
I_e	37 to 69	2

Table E.2 — Reminder of initial repeatability and reproducibility equations for commercial flour (data from the initial ring test)

Parameter	Validity range of the interlaboratory test	s_r	s_R
W	190 to 415	0,054 1 W – 1,571 5	0,059 5 W + 0,569 6
P	70 to 118	0,017 3 P + 0,310 7	0,032 9 P – 0,568 6
L	78 to 98	0,144 9 L – 7,083	0,139 3 L – 5,132 1
G	19,5 to 21,5	0,121 8 G – 1,861 7	0,115 7 G – 1,560 8
P/L	0,92 to 1,28	0,125 P/L – 0,06	0,125 P/L – 0,04

Table E.3 — Practical application of repeatability equations for commercial flour (data from the interlaboratory test)

W Validity range: **190 to 415**		P Validity range: **70 to 118**		L Validity range: **78 to 98**		G Validity range: **19,5 to 21,5**		P/L Validity range: **0,92 to 1,28**	
s_r = 0,054 1 W – 1,571 5		s_r = 0,017 3 P + 0,310 7		s_r = 0,144 9 L – 7,083		s_r = 0,121 8 G – 1,861 7		s_r = 0,125 P/L – 0,06	
W 10^{-4} J	**Repeatability limit** (r = 2,77 s_r)	P mm	**Repeatability limit** (r = 2,77 s_r)	L mm	**Repeatability limit** (r = 2,77 s_r)	G ml	**Repeatability limit** (r = 2,77 s_r)	P/L	**Repeatability limit** (r = 2,77 s_r)
190	24	70	4	78	12	19,5	1,4	0,92	0,15
200	26	72	4	79	12	19,6	1,5	0,94	0,16
210	27	74	4	80	12	19,7	1,5	0,95	0,16
220	29	76	5	81	13	19,8	1,5	0,97	0,17
230	30	78	5	82	13	19,9	1,6	0,98	0,17
240	32	80	5	83	14	20,0	1,6	1,00	0,18
250	33	82	5	84	14	20,1	1,6	1,01	0,18
260	35	84	5	85	14	20,2	1,7	1,03	0,19
270	36	86	5	86	15	20,3	1,7	1,04	0,19
280	38	88	5	87	15	20,4	1,7	1,06	0,20
290	39	90	5	88	16	20,5	1,8	1,07	0,20
300	41	92	5	89	16	20,6	1,8	1,09	0,21
310	42	94	5	90	17	20,7	1,8	1,10	0,21
320	44	96	5	91	17	20,8	1,9	1,12	0,22
330	45	98	6	92	17	20,9	1,9	1,13	0,23
340	47	100	6	93	18	21,0	1,9	1,15	0,23
350	48	102	6	94	18	21,1	2,0	1,16	0,24

Table E.3 *(continued)*

W Validity range: 190 to 415		*P* Validity range: 70 to 118		*L* Validity range: 78 to 98		*G* Validity range: 19,5 to 21,5		*P/L* Validity range: 0,92 to 1,28	
s_r = 0,054 1 *W* − 1,571 5		s_r = 0,017 3 *P* + 0,310 7		s_r = 0,144 9 *L* − 7,083		s_r = 0,121 8 *G* − 1,861 7		s_r = 0,125 *P/L* − 0,06	
W 10^{-4} J	Repeatability limit (r = 2,77 s_r)	*P* mm	Repeatability limit (r = 2,77 s_r)	*L* mm	Repeatability limit (r = 2,77 s_r)	*G* ml	Repeatability limit (r = 2,77 s_r)	*P/L*	Repeatability limit (r = 2,77 s_r)
360	50	104	6	95	19	21,2	2,0	1,18	0,24
370	51	106	6	96	19	21,3	2,0	1,19	0,25
380	53	108	6	97	19	21,4	2,1	1,21	0,25
390	54	110	6	98	20	21,5	2,1	1,22	0,26
400	56	112	6					1,24	0,26
410	57	114	6					1,25	0,27
415	58	116	6					1,27	0,27
		118	7					1,28	0,28

Table E.4 — Practical application of reproducibility equations for commercial flour (data from the proficiency tests)

W **Validity range:** **83 to 383**		*P* **Validity range:** **35 to 131**		*L* **Validity range:** **50 to 134**		*G* **Validity range:** **15,7 to 25,7**		*P/L* **Validity range:** **0,30 to 2,65**		l_e **Validity range:** **37 to 69**	
$s_R = 0{,}0629\ W + 1{,}5054$		$s_R = 0{,}045\ P + 0{,}15$		$s_R = 0{,}06\ L + 1{,}81$		$s_R = 0{,}8$		$s_R = 0{,}121\ P/L - 0{,}018$		$s_R = 2$	
W 10^{-4} J	**Repeatability limit** $R = s_R \times 2{,}77$	*P* mm	**Repeatability limit** $R = s_R \times 2{,}77$	*L* mm	**Repeatability limit** $R = s_R \times 2{,}77$	*G* ml	**Repeatability limit** $R = s_R \times 2{,}77$	*P/L*	**Repeatability limit** $R = s_R \times 2{,}77$	l_e %	**Repeatability limit** $R = s_R \times 2{,}77$
80	23	30	4	50	13	15,6	2,2	0,30	0,05	61,70	5,54
85	24	32	4	52	18	15,8	2,2	0,35	0,07	61,95	5,54
90	25	34	5	54	19	16	2,2	0,40	0,08	62,20	5,54
95	26	36	5	56	19	16,2	2,2	0,45	0,10	62,45	5,54
100	26	38	5	58	20	16,4	2,2	0,50	0,12	62,70	5,54
105	27	40	5	60	20	16,6	2,2	0,55	0,13	62,95	5,54
110	28	42	6	62	21	16,8	2,2	0,60	0,15	63,20	5,54
115	29	44	6	64	21	17	2,2	0,65	0,17	63,40	5,54
120	29	46	6	66	22	17,2	2,2	0,70	0,18	63,70	5,54
125	30	48	6	68	22	17,4	2,2	0,75	0,20	63,95	5,54
130	31	50	7	70	23	17,6	2,2	0,80	0,22	64,20	5,54
135	32	52	7	72	24	17,8	2,2	0,85	0,24	64,45	5,54
140	32	54	7	74	24	18	2,2	0,90	0,25	64,70	5,54
145	33	56	7	76	25	18,2	2,2	0,95	0,27	64,95	5,54
150	34	58	8	78	25	18,4	2,2	1,00	0,29	65,20	5,54
155	35	60	8	80	26	18,6	2,2	1,05	0,30	65,45	5,54
160	35	62	8	82	26	18,8	2,2	1,10	0,32	65,70	5,54
165	36	64	8	84	27	19	2,2	1,15	0,34	65,95	5,54
170	37	66	9	86	27	19,2	2,2	1,20	0,35	66,20	5,54
175	38	68	9	88	28	19,4	2,2	1,25	0,37	66,45	5,54
180	38	70	9	90	29	19,6	2,2	1,30	0,39	66,70	5,54
185	39	72	9	92	29	19,8	2,2	1,35	0,40	66,95	5,54
190	40	74	10	94	30	20	2,2	1,40	0,42	67,20	5,54
195	40	76	10	96	30	20,2	2,2	1,45	0,44	67,45	5,54
200	41	78	10	98	31	20,4	2,2	1,50	0,45	67,70	5,54

Table E.4 *(continued)*

W Validity range: 83 to 383		*P* Validity range: 35 to 131		*L* Validity range: 50 to 134		*G* Validity range: 15,7 to 25,7		*P/L* Validity range: 0,30 to 2,65		l_e Validity range: 37 to 69	
s_R = 0,0629 *W* + 1,5054		s_R = 0,045 *P* + 0,15		s_R = 0,06 *L* + 1,81		s_R = 0,8		s_R = 0,121 *P/L* – 0,018		s_R = 2	
W 10^{-4} J	Repeatability limit $R = s_R \times 2,77$	*P* mm	Repeatability limit $R = s_R \times 2,77$	*L* mm	Repeatability limit $R = s_R \times 2,77$	*G* ml	Repeatability limit $R = s_R \times 2,77$	*P/L*	Repeatability limit $R = s_R \times 2,77$	l_e %	Repeatability limit $R = s_R \times 2,77$
205	42	80	10	100	31	20,6	2,2	1,55	0,47	67,95	5,54
210	43	82	11	102	32	20,8	2,2	1,60	0,49	68,20	5,54
215	43	84	11	104	32	21	2,2	1,65	0,50	68,45	5,54
220	44	86	11	106	33	21,2	2,2	1,70	0,52	68,70	5,54
225	45	88	11	108	34	21,4	2,2	1,75	0,54	68,95	5,54
230	46	90	12	110	34	21,6	2,2	1,80	0,55	69,20	5,54
235	46	92	12	112	35	21,8	2,2	1,85	0,57	69,45	5,54
240	47	94	12	114	35	22	2,2	1,90	0,59	69,70	5,54
245	48	96	12	116	36	22,2	2,2	1,95	0,60	69,95	5,54
250	49	98	13	118	36	22,4	2,2	2,00	0,62	70,20	5,54
255	49	100	13	120	37	22,6	2,2	2,05	0,64	70,45	5,54
260	50	102	13	122	37	22,8	2,2	2,10	0,65	70,70	5,54
265	51	104	13	124	38	23	2,2	2,15	0,67	70,95	5,54
270	52	106	14	126	39	23,2	2,2	2,20	0,69	71,20	5,54
275	52	108	14	128	39	23,4	2,2	2,25	0,70	71,45	5,54
280	53	110	14	130	40	23,6	2,2	2,30	0,72	71,70	5,54
285	54	112	14	132	40	23,8	2,2	2,35	0,74		
290	55	114	15	134	41	24	2,2	2,40	0,75		
295	55	116	15			24,2	2,2	2,45	0,77		
300	56	118	15			24,4	2,2	2,50	0,79		
305	57	120	15			24,6	2,2	2,55	0,80		
310	57	122	16			24,8	2,2	2,60	0,82		
315	58	124	16			25	2,2	2,65	0,84		
320	59	126	16			25,2	2,2	2,70	0,86		

Table E.4 *(continued)*

W Validity range: 83 to 383		*P* Validity range: 35 to 131		*L* Validity range: 50 to 134		*G* Validity range: 15,7 to 25,7		*P/L* Validity range: 0,30 to 2,65		l_e Validity range: 37 to 69	
$s_R = 0{,}0629\ W + 1{,}5054$		$s_R = 0{,}045\ P + 0{,}15$		$s_R = 0{,}06\ L + 1{,}81$		$s_R = 0{,}8$		$s_R = 0{,}121\ P/L - 0{,}018$		$s_R = 2$	
W 10^{-4} J	**Repeatability limit** $R = s_R \times 2{,}77$	*P* mm	**Repeatability limit** $R = s_R \times 2{,}77$	*L* mm	**Repeatability limit** $R = s_R \times 2{,}77$	*G* ml	**Repeatability limit** $R = s_R \times 2{,}77$	*P/L*	**Repeatability limit** $R = s_R \times 2{,}77$	l_e %	**Repeatability limit** $R = s_R \times 2{,}77$
325	60	128	16			25,4	2,2				
330	60	130	17			25,6	2,2				
335	61	132	17			25,8	2,2				
340	62										
345	63										
350	63										
355	64										
360	65										
365	66										
370	66										
375	67										
380	68										
385	69										

Annex F
(informative)

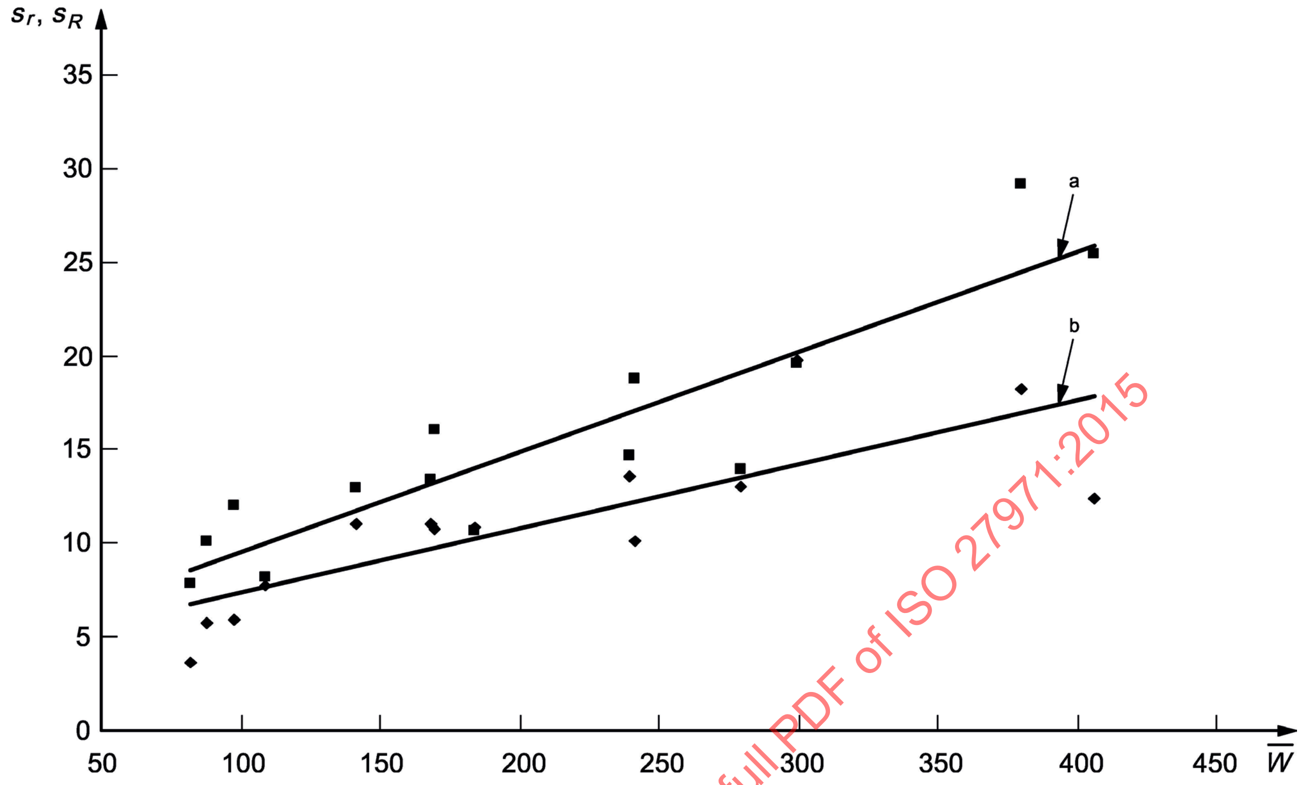
Interlaboratory data for laboratory milled flour

The repeatability and reproducibility limits of the method used for flour obtained from laboratory milling were established by two interlaboratory tests performed in 2001 and 2004 according to ISO 5725-2,[3] ISO 5725-3[4], and ISO 5725-6.[5]

Ten laboratories participated in the first test campaign and 12 in the second. Fourteen wheat samples were analysed and the test was repeated three times for each one. The statistical results of the tests are set out below.

Table F.1 — Statistical results for *W* on laboratory milled flour

Wheat	10	7	8	5	1	2	12	3	11	4	14	9	13	6
No. laboratories	10	10	10	10	9	10	10	10	10	9	10	10	10	10
Mean, $\overline{W}$	82	88	98	109	141	168	170	184	240	242	279	300	380	406
s_r	4	6	6	8	11	11	11	11	14	10	13	20	18	12
CV(r) %	4	6	6	7	8	7	6	6	6	4	5	7	5	3
r	10	16	16	22	31	31	30	30	38	28	36	55	51	34
s_R	8	10	12	8	13	13	16	11	15	19	14	20	29	25
CV(R) %	10	12	12	7	9	8	9	6	6	8	5	7	8	6
R	22	28	33	23	36	37	45	30	41	52	39	54	81	70



Key

$\overline{W}$ mean of W

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_R; $y = 0{,}053\ 4\ x + 4{,}195\ 1$; $R^2 = 0{,}821\ 1$ (correlation coefficient).

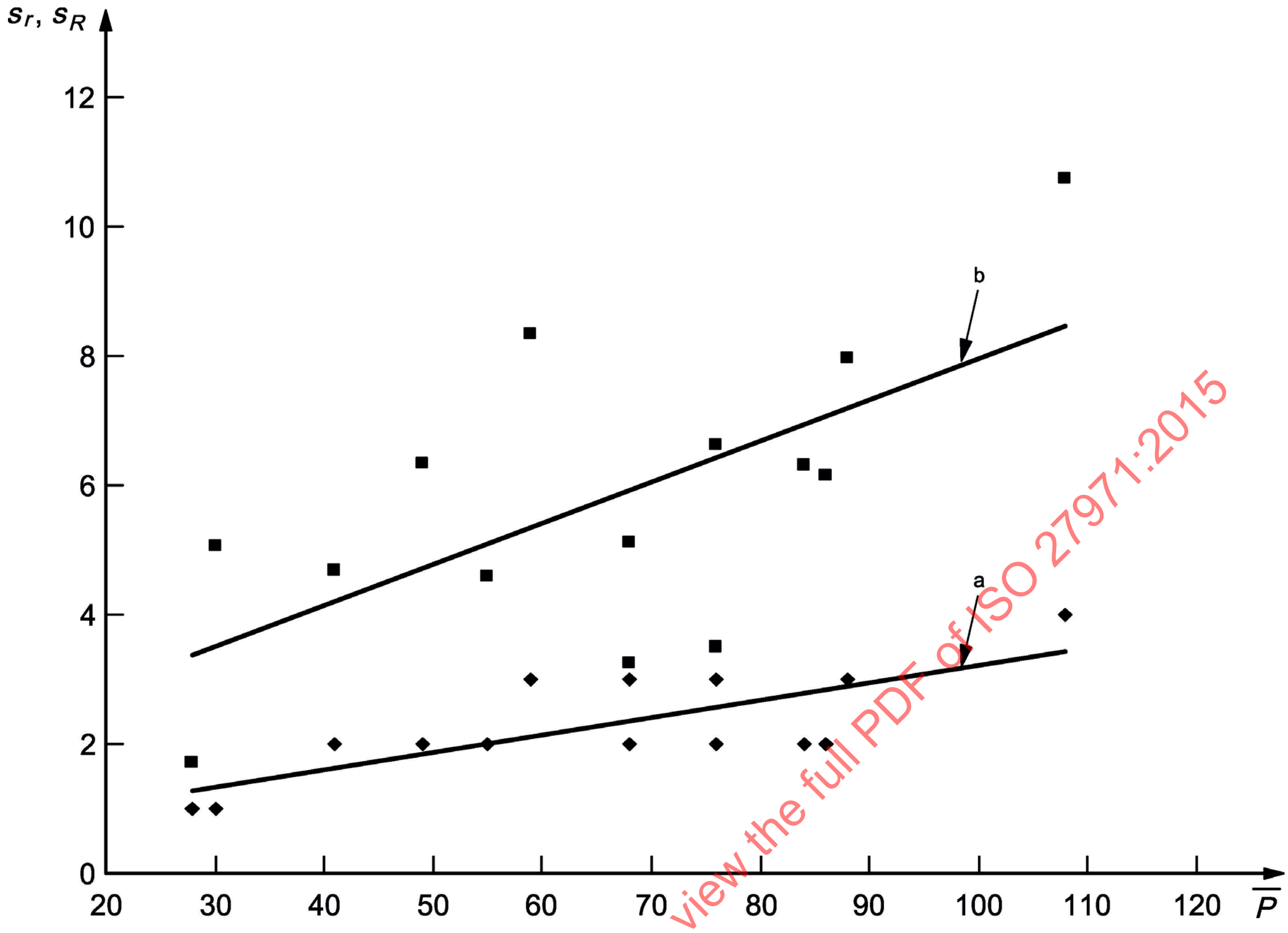
b s_r; $y = 0{,}034\ 4\ x + 3{,}903\ 8$; $R^2 = 0{,}655$ (correlation coefficient).

Figure F.1 — Relationship between precision standard deviations and mean values of *W*

Figure F.1 shows that the standard deviations of repeatability and reproducibility are dependent on the mean values of *W*.

Table F.2 — Statistical results for *P* on laboratory milled flour

Wheat	5	8	10	12	4	7	1	2	3	13	14	6	11	9
No. laboratories	10	10	10	10	9	10	9	9	10	10	10	10	10	10
Mean, $\overline{P}$	28	30	41	49	55	59	68	68	76	76	84	86	88	108
s_r	1	1	2	2	2	3	3	2	2	3	2	2	3	4
CV(r) %	2	4	4	3	3	5	5	3	3	4	3	2	4	4
r	2	4	5	4	4	9	9	5	6	8	7	6	10	11
s_R	2	5	5	6	5	8	5	3	4	7	6	6	8	11
CV(R) %	6	17	11	13	8	14	8	5	5	9	8	7	9	10
R	5	14	13	18	13	23	14	9	10	18	17	17	22	30



Key

$\overline{P}$ mean of P

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = 0{,}026\ 8\ x + 0{,}535$; $R^2 = 0{,}565\ 8$ (correlation coefficient).

b s_R; $y = 0{,}063\ 7\ x + 1{,}579\ 9$; $R^2 = 0{,}411\ 8$ (correlation coefficient).

Figure F.2 — Relationship between precision standard deviations and mean values of *P*

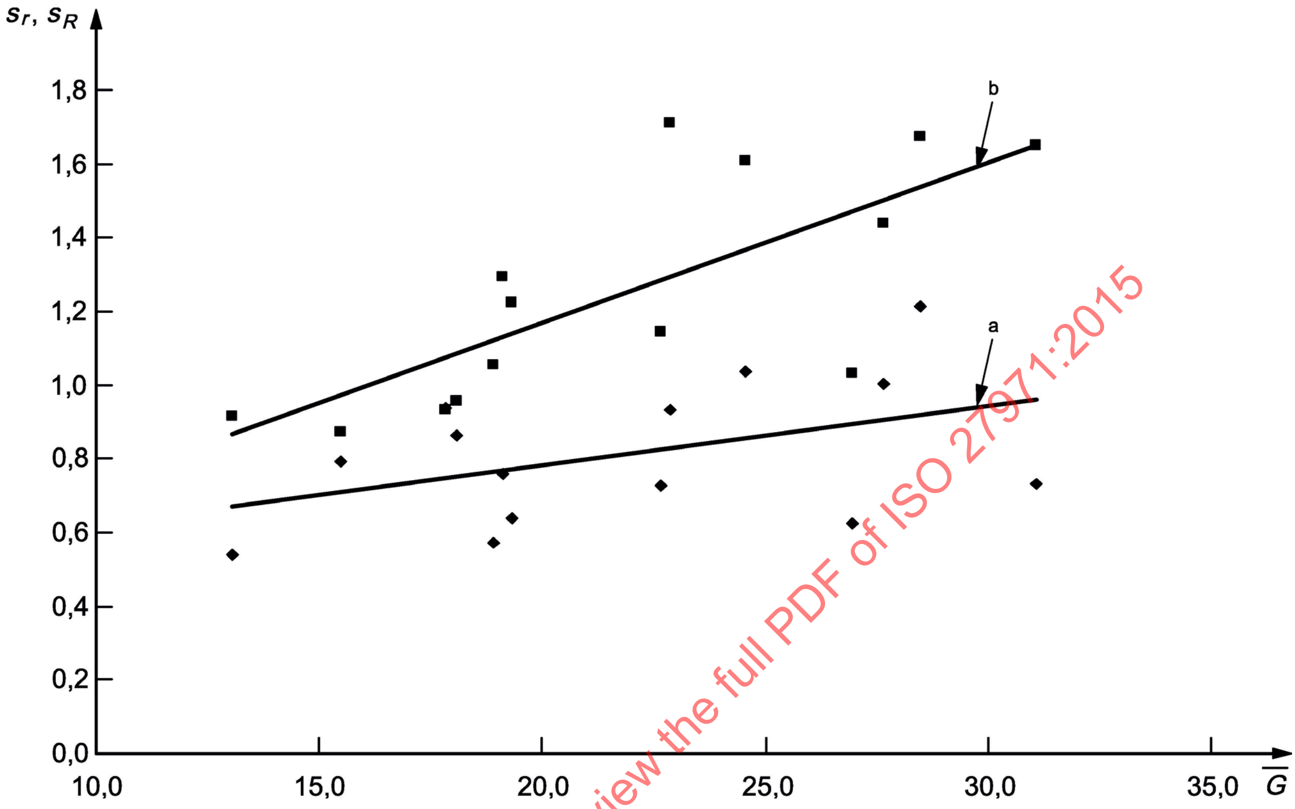
Figure F.2 shows that the standard deviations of repeatability and reproducibility are dependent on the mean values of *P*.

Table F.3 — Statistical results for *G* on laboratory milled flour

Wheat	7	1	3	2	11	9	10	14	8	12	6	5	13	4
No. laboratories	10	9	10	10	10	10	10	10	10	10	10	10	10	9
Mean, $\overline{G}$	13,1	15,5	17,8	18,1	18,9	19,1	19,3	22,7	22,9	24,6	26,9	27,7	28,5	31,1
s_r	0,5	0,8	0,9	0,9	0,6	0,8	0,6	0,7	0,9	1,0	0,6	1,0	1,2	0,7
CV(*r*) %	4,1	5,1	5,3	4,8	3,0	4,0	3,3	3,2	4,1	4,2	2,3	3,6	4,3	2,4
r	1,5	2,2	2,6	2,4	1,6	2,1	1,8	2,0	2,6	2,9	1,7	2,8	3,4	2,0
s_R	0,9	0,9	0,9	1,0	1,1	1,3	1,2	1,1	1,7	1,6	1,0	1,4	1,7	1,6
CV(*R*) %	7,0	5,6	5,2	5,3	5,6	6,8	6,3	5,0	7,5	6,5	3,8	5,2	5,9	5,3

Table F.3 *(continued)*

R	2,5	2,4	2,6	2,7	2,9	3,6	3,4	3,2	4,7	4,5	2,9	4,0	4,6	4,6



Key

$\bar{G}$ mean of *G*

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = 0{,}016\,x + 0{,}462\,6$; $R^2 = 0{,}19$ (correlation coefficient).

b s_R; $y = 0{,}043\,7\,x + 1{,}295\,2$; $R^2 = 0{,}559\,4$ (correlation coefficient).

Figure F.3 — Relationship between precision standard deviations and mean values of *G*

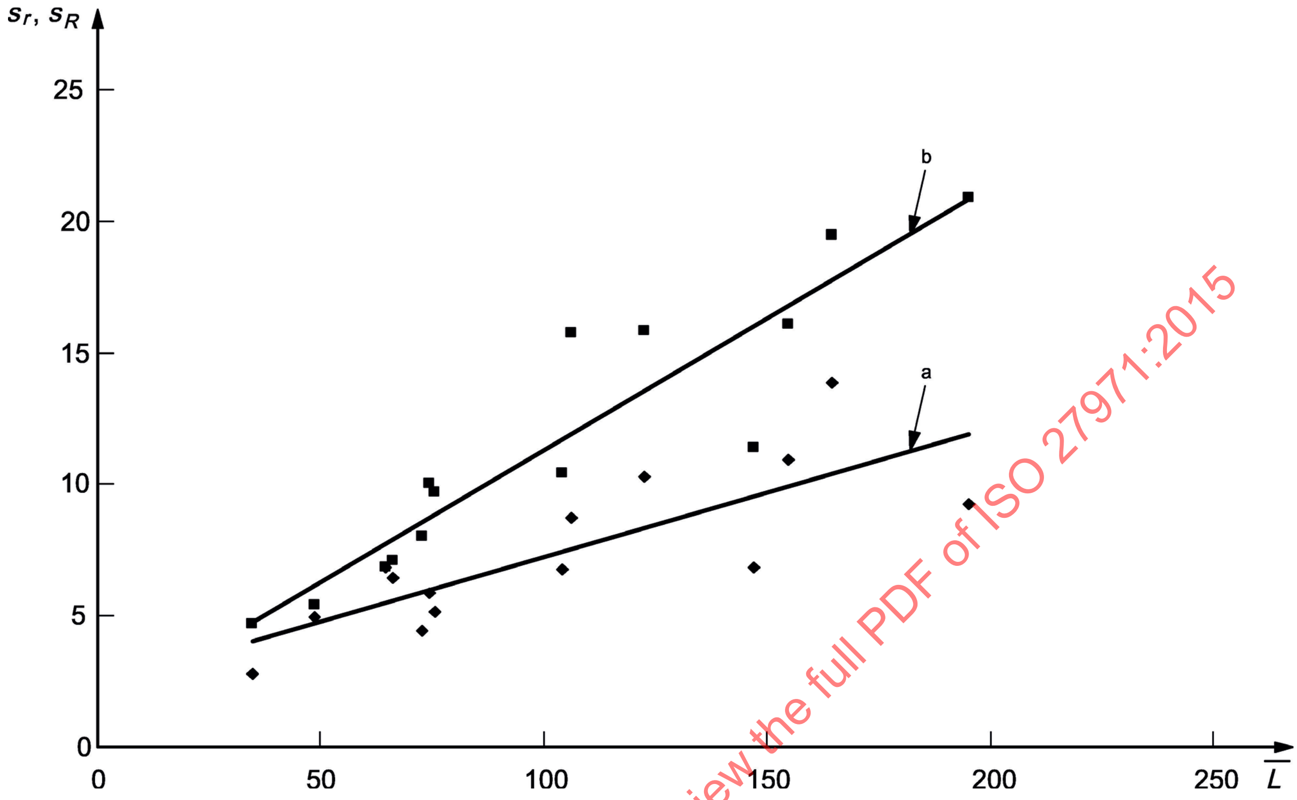
The standard deviations of repeatability and reproducibility had been considered as constant irrespective of the mean of *G* (see Figure F.3) and based on the conclusion os the two interlaboratory tests.

Table F.4 — Statistical results for *L* on laboratory milled flour

Wheat	7	1	3	2	11	9	10	14	8	12	6	5	13	4
No. laboratories	10	9	10	10	10	10	10	10	10	10	10	10	10	9
Mean, $\bar{L}$	35	49	64	66	73	74	76	104	106	123	147	155	164	195
s_r	3	5	7	6	4	6	5	7	9	10	7	11	14	9
CV(*r*) %	8	10	11	10	6	8	7	7	8	8	5	7	8	5
r	8	14	19	18	12	16	14	19	24	28	19	30	38	26
s_R	5	5	7	7	8	10	10	10	16	16	11	16	19	21
CV(*R*) %	14	11	11	11	11	13	13	10	15	13	8	10	12	11

Table F.4 *(continued)*

R	13	15	19	20	22	28	27	29	44	44	32	44	54	58



Key

$\bar{L}$ mean of *L*

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = 0{,}049\,x + 2{,}347\,1$; $R^2 = 0{,}644$ (correlation coefficient).

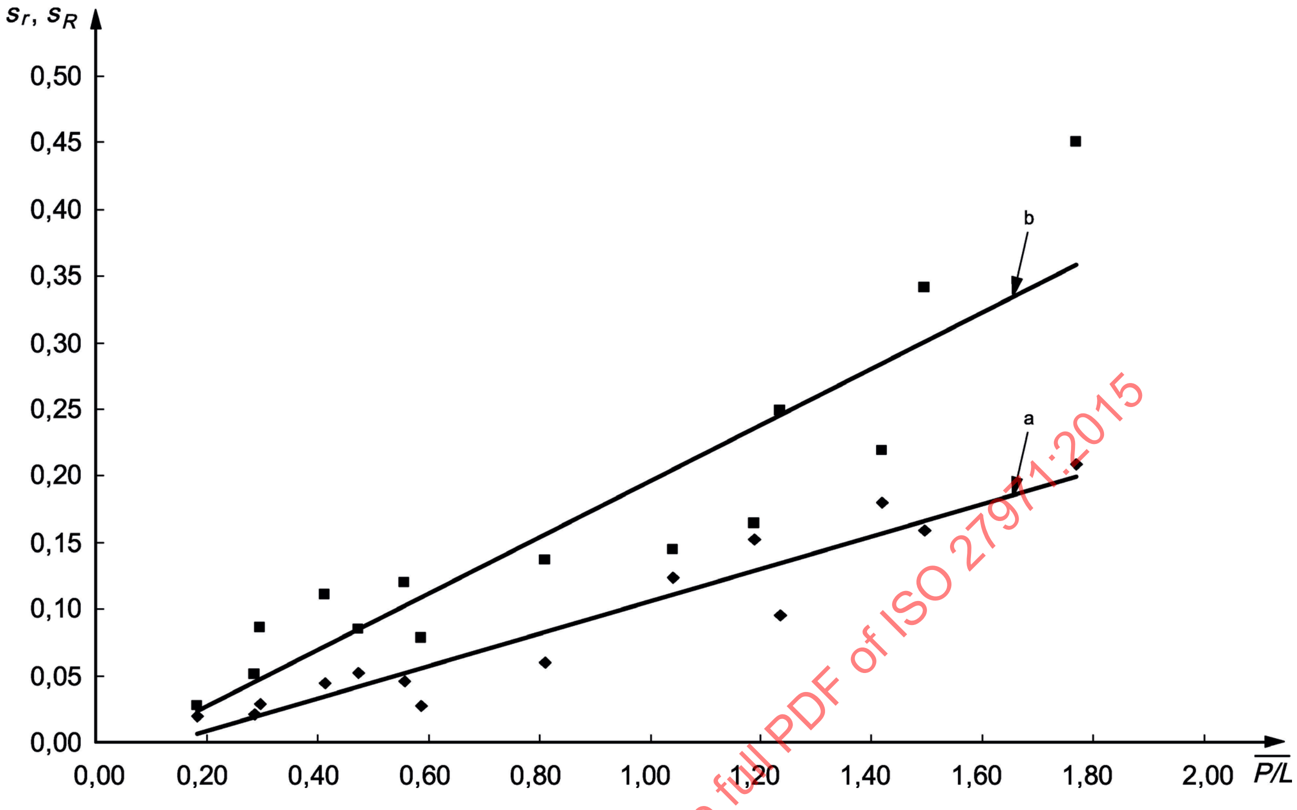
b s_R; $y = 0{,}099\,8\,x + 1{,}331\,1$; $R^2 = 0{,}857\,1$ (correlation coefficient).

Figure F.4 — Relationship between precision standard deviations and mean values of *L*

Figure F.4 shows that the standard deviations of repeatability and reproducibility are dependent on the mean values of *L*.

Table F.5 — Statistical results for *P/L* on laboratory milled flour

Wheat	5	4	8	12	13	10	6	14	2	3	11	1	9	7
No. laboratories	10	9	10	10	10	10	10	10	10	10	10	9	10	10
Mean, $\overline{P/L}$	0,18	0,29	0,30	0,41	0,47	0,56	0,59	0,81	1,04	1,19	1,24	1,42	1,49	1,77
s_r	0,02	0,02	0,03	0,04	0,05	0,05	0,03	0,06	0,12	0,15	0,10	0,18	0,16	0,21
CV(*r*) %	10,28	7,15	9,62	10,66	10,98	8,26	4,72	7,29	11,83	12,87	7,71	12,64	10,60	11,75
r	0,05	0,06	0,08	0,12	0,14	0,13	0,08	0,16	0,34	0,42	0,26	0,50	0,44	0,58
s_R	0,03	0,05	0,09	0,11	0,09	0,12	0,08	0,14	0,14	0,16	0,25	0,22	0,34	0,45
CV(*R*) %	15,11	17,74	28,88	26,83	17,93	21,58	13,23	16,74	13,90	13,82	20,08	15,46	22,84	25,42
R	0,08	0,14	0,24	0,31	0,24	0,33	0,22	0,38	0,40	0,46	0,69	0,61	0,95	1,25



Key

$\overline{P/L}$ mean of P/L

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = 0{,}121\ 5\ x - 0{,}015\ 4$; $R^2 = 0{,}915\ 1$ (correlation coefficient).

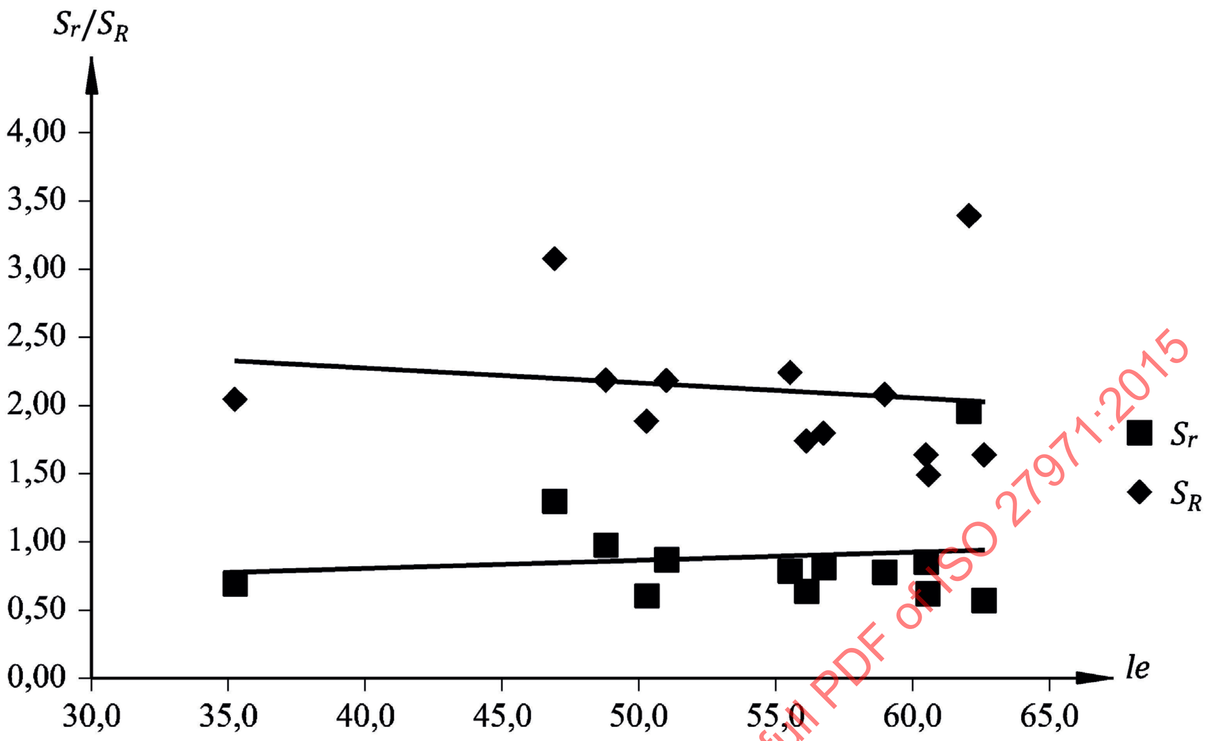
b s_R; $y = 0{,}210\ 7\ x - 0{,}015\ 4$; $R^2 = 0{,}846\ 4$ (correlation coefficient).

Figure F.5 — Relationship between precision standard deviations and mean values of P/L

Figure F.5 shows that the standard deviations of repeatability and reproducibility are dependent on the mean values of P/L.

Table F.6 — Statistical results for I_e on laboratory milled flour

Wheat	1	4	5	4	6	2	2	8	3	5	7	3	1	6
No. laboratories	—	10	10	9	10	10	10	9	9	10	9	10	8	10
Mean, $\overline{I_e}$	—	35,3	46,9	48,7	50,3	50,9	55,5	56,1	56,7	59,0	60,4	60,5	62,0	62,6
s_r	—	0,71	1,30	0,98	0,61	0,88	0,80	0,64	0,82	0,80	0,86	0,63	1,97	0,58
CV(r) %	—	2,01	2,78	2,01	1,20	1,72	1,43	1,14	1,44	1,35	1,42	1,04	3,17	0,92
r	—	1,96	3,61	2,72	1,68	2,43	2,21	1,77	2,26	2,21	2,39	1,75	5,46	1,60
s_R	—	2,06	3,09	2,19	1,90	2,20	2,25	1,75	1,81	2,09	1,65	1,50	3,42	1,64
CV(R) %	—	5,85	6,58	4,50	3,78	4,31	4,05	3,13	3,19	3,54	2,73	2,48	5,51	2,62
R	—	5,72	8,56	6,07	5,27	6,09	6,23	4,86	5,01	5,79	4,56	4,15	9,47	4,54



Key

$\overline{I_e}$ mean of I_e

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = 0{,}0054\,x + 0{,}5937$; $R^2 = 0{,}0124$ (correlation coefficient).

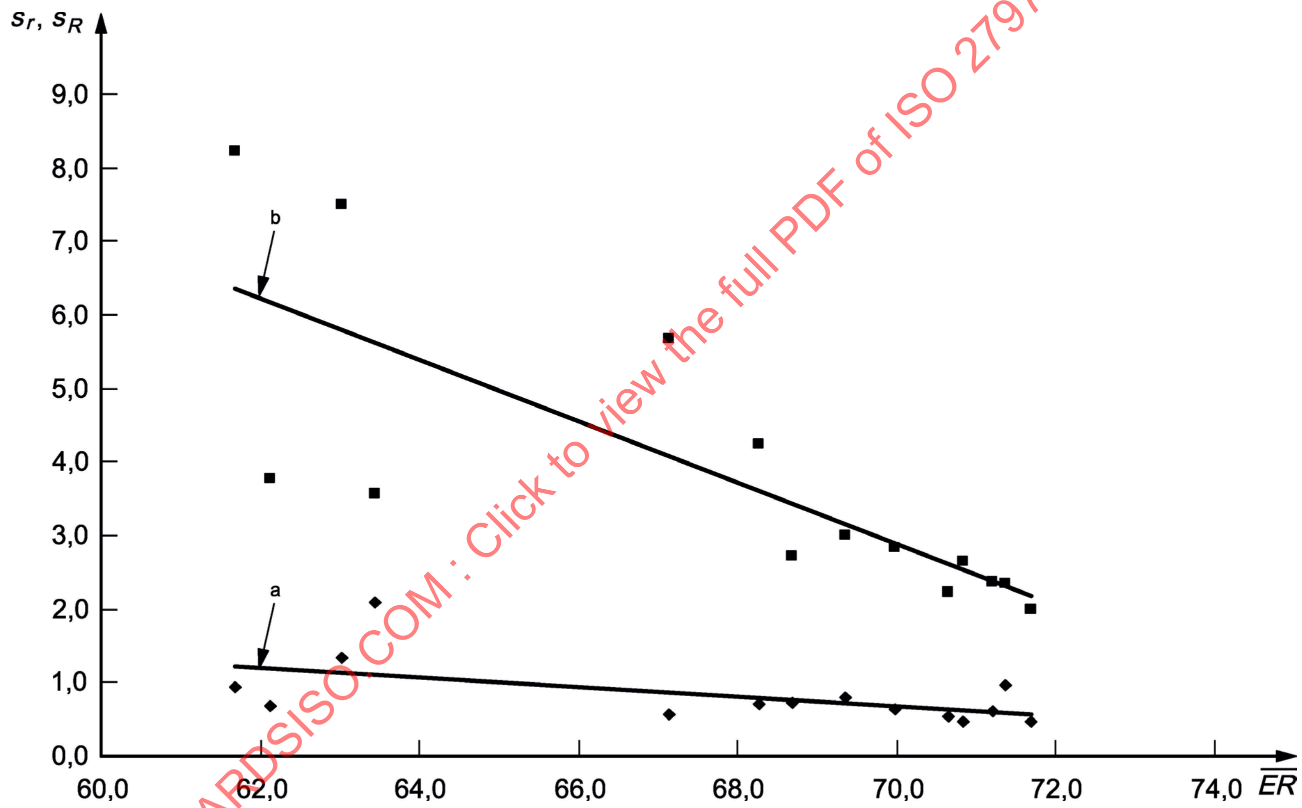
b s_R; $y = -0{,}0112\,x + 2{,}7252$; $R^2 = 0{,}0237$ (correlation coefficient).

Figure F.6 — Relationship between precision standard deviations and mean values of I_e

Figure F.6 shows that the standard deviations of repeatability and reproducibility are considered to be constant irrespective of the mean value of I_e.

Table F.7 — Statistical results for the extraction rate from laboratory milled flour

Wheat	7	14	11	10	12	8	13	2	9	6	3	4	5	1
No. laboratories	9	8	10	8	9	10	9	10	9	10	9	10	10	10
Mean, $\overline{ER}$	61,7	62,1	63,0	63,4	67,1	68,0	68,7	69,4	70,0	70,7	70,8	71,2	71,4	71,7
s_r	0,9	0,7	1,3	2,1	0,6	1,0	0,7	0,8	0,6	0,5	0,5	0,6	1,0	0,5
CV(r) %	1,5	1,1	2,1	3,3	0,8	1,0	1,1	1,2	0,9	0,8	0,7	0,9	1,3	0,7
r	2,6	1,9	3,7	5,8	1,6	2,0	2,0	2,2	1,7	1,5	1,3	1,7	2,7	1,3
s_R	8,2	3,8	7,5	3,6	5,7	4,0	2,7	3,0	2,8	2,2	2,6	2,4	2,4	2,0
CV(R) %	13,3	6,1	11,9	5,6	8,4	6,0	3,9	4,3	4,1	3,1	3,7	3,3	3,3	2,8
R	22,8	10,5	20,8	9,9	15,7	12,0	7,5	8,3	7,9	6,2	7,3	6,6	6,5	5,5



Key

$\overline{ER}$ mean of ER

s_r standard deviation of repeatability

s_R standard deviation of reproducibility

a s_r; $y = -0{,}065\,8\,x + 5{,}285\,9$; $R^2 = 0{,}321\,1$ (correlation coefficient).

b s_R; $y = -0{,}417\,9\,x + 32{,}134$; $R^2 = 0{,}606\,3$ (correlation coefficient).

Figure F.7 — Relationship between precision standard deviations and mean extraction rate values

The standard deviations of repeatability and reproducibility had been considered as constant irrespective of the mean of extraction rate (see Figure F.7) and based on the conclusion os the two interlaboratory tests.