INTERNATIONAL STANDARD

**ISO 27971**

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

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 34, *Food products*, Subcommittee SC 4, *Cereals and pulses*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 338, *Cereal and cereal products,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 27971:2015), which has been technically revised.

The main changes are as follows:

— the oldest instruments (before AlveoNG) have been removed;

— the latest instruments (AlveoPC and Alveolab) have been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# 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 bread dough 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 stiffness. 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 mean of the abscissa value at rupture, $L$, converted to the swelling index, $G$.

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, or its strength, 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 stiffness 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;

— assessing the proteolytic activity in wheat or flour to detect possible contamination (see Annex H for more details).

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 References [9], [11], [12] and [13]).

# 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 document 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;

— 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.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 835, *Laboratory glassware — Graduated pipettes*

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

ISO 1042, *Laboratory glassware — One-mark volumetric flasks*

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

## 3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

## 4 Principle

The behaviour of dough obtained from a mixture of flour and salt water is evaluated during deformation. A dough disk (patty) 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".

## 5 Reagents

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

**5.1 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 days and its temperature shall be (20 ± 2) °C when used.

**5.2 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 in accordance with ISO 660[1]). 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].

**5.3 Cold degreasing agent**, optimum safety.

## 6 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used.

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

**6.2 Conical or riffle sample divider.**

**6.3 Analytical balance**, accurate to 0,01 g.

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

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

**6.5.1 Constant speed stirrer.**

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

**6.5.3 Several wide-necked plastic flasks**, 2 l capacity.

**6.6 Test mill (laboratory mill)**[2)], manually or automatically operated (see Annex A).

1) The CHOPIN Technologies MR2L rotary blender is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

2) The CHOPIN Technologies Chopin-Dubois CD1 test mill is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

**6.7 Complete Alveograph system** (see Table 1 for specifications and characteristics of the accessories) including the devices given in 6.7.1 to 6.7.3.

**6.7.1 Kneading machine** (see Figure 1 for the AlveoNG and AlveoPC models, and Figure 2 for the Alveolab model[3)]), with accurate temperature control, for dough sample preparation.

**6.7.2 Dedicated software,** to record the pressure curve as a function of time, perform the calculations and store the tests or other registration systems such as the Alveolink.

NOTE For details concerning the use of the different registration systems, see the manufacturer's instructions.

**6.7.3 Alveograph**[3)], for measuring the biaxial deformation of the dough test pieces (see Figure 1 for the AlveoNG and AlveoPC models, and Figure 2 for the Alveolab model), including accurate temperature control and hygrometry control for the Alveolab model, and having two rest chambers (three for the Alveolab), each containing five plates on which the dough test pieces can be arranged to rest prior to deformation.

**6.8 Burette with stopcock**, supplied with the apparatus (only for the AlveoNG and AlveoPC models), 160 ml capacity, graduated in divisions of 0,1 % of moisture content.

NOTE Throughout this document, "content" is expressed as a "mass fraction" (see ISO 80000-9[8]), i.e. the ratio of the mass of substance in a mixture to the total mass of the mixture.

**6.9 Thermohydrograph for recording the test environment conditions** (temperature and relative air humidity) as specified in 9.1 and 10.1. In the case of the Alveolab, the test conditions (temperature and humidity) around the swelling bubble are automatically checked and controlled by the device.

**6.10 Volumetric flask**, 1 000 ml capacity, conforming to the requirements of ISO 1042, class A.

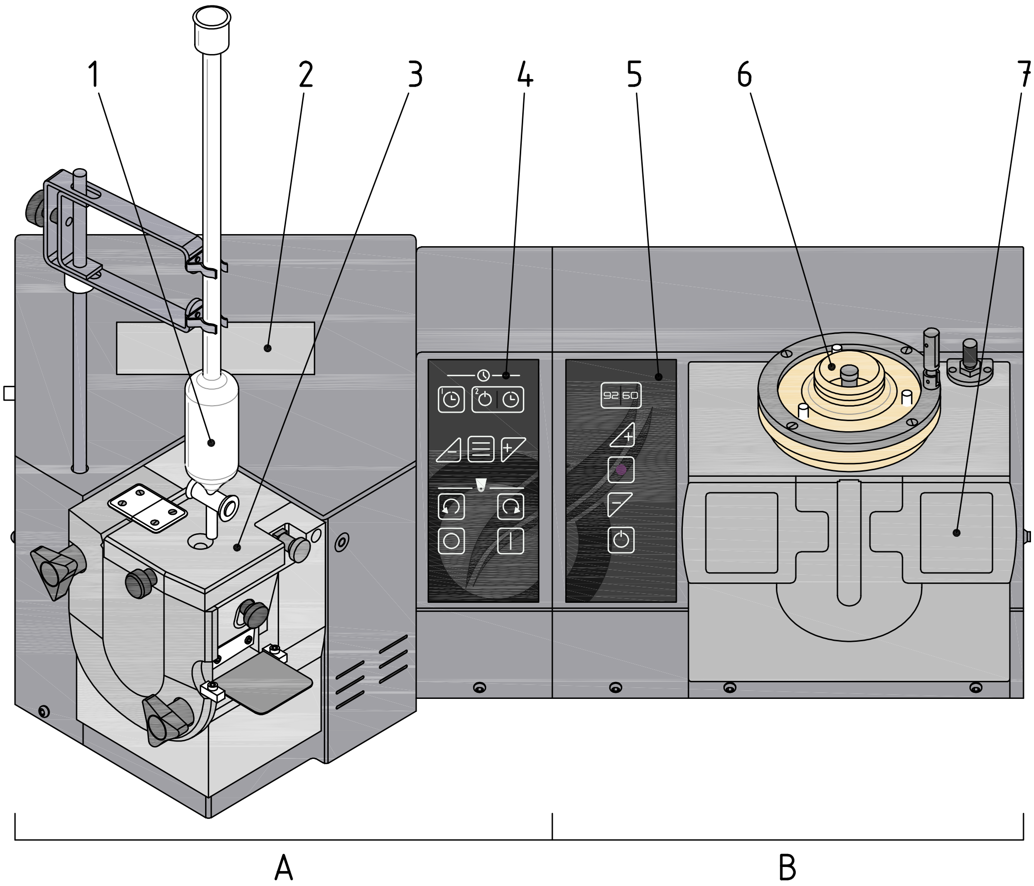
**6.11 Pipette**, 25 ml capacity, graduated in divisions of 0,1 ml, conforming to the requirements of ISO 835, class A.

3) The methods specified in this document are based on the use of the AlveoNG, AlveoPC and Alveolab models of the CHOPIN Technologies Alveograph, which are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

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

| Quantity | Value and tolerance |
|---|---|
| Rotational frequency of the kneading 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 | (18 ± 2) ml |
| Air flow[a] ensuring inflation | (96 ± 2) l/h |
| [a] On the AlveoNG and AlveoPC models, to adjust the flow rate of the air generator used to inflate the bubble, fit the nozzle (see Figure 3) to create a specified pressure drop (and obtain a pressure corresponding to a height of 92 mm$H_2O$ (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 mm $H_2O$ (8,0 kPa) on the manometer chart, i.e. (96 ± 2) l/h (see Figure 4). For the Alveolab model, this control is automatized, and no particular action is required. | |




**Key**

A mixer

B Alveograph

1 burette for adding water

2 mixer screen

4 mixer control panel

5 Alveograph control panel

6 test plate of the Alveograph unit

7 resting chamber

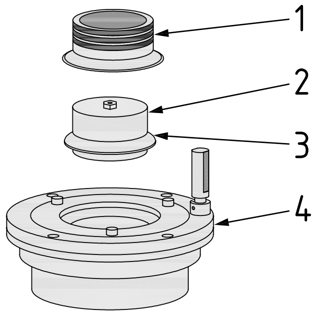
3 mixing bowl

**Figure 1 — Mixer and Alveograph part of the AlveoNG and AlveoPC models**


**Key**

1 mixing bowl
2 water injection nozzle
3 Aveolab control panel
4 Alveograph test chamber
5 storage compartment for accessories
6 dough collector and humidifier
7 resting chamber
8 salt water tank

**Figure 2 — Mixer and Alveograph part of the Alveolab model**




**Key**

1 knurled ring

2 nozzle

3 nozzle holder

4 top plate

**Figure 3 — Flow control system for the AlveoNG or AlveoPC models**

# 7 Sampling

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

Sampling is not part of the method specified in this document. Recommended sampling methods are given in ISO 24333[7].

# 8 Preparation of the wheat for laboratory milling

## 8.1 Cleaning the laboratory sample

If necessary, pass the laboratory sample through a mechanical cleaner (6.1) 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.

## 8.2 Test portion

The test portion shall be representative of the initial wheat mass. Use the sample divider (6.2) 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.

## 8.3 Wheat moisture content determination

Determine the moisture content of the test portion as specified in ISO 712, or using a rapid device (see ISO 7700-1[6] or ISO 12099).

## 8.4 Wheat preparation

### 8.4.1 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) %.

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

Using the balance (6.3), 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 (6.4) 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 (6.5).

Run the rotary blender for (30 ± 5) min (the 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.

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

Since 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 8.4.2, using only half the total quantity of water required (see Table B.1).

Shake the flask as described in 8.4.2 and allow it to rest for at least 6 h.

Then add the second half of the total quantity of water between the sixth and seventh 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.

#### 8.4.4 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 (see 8.3).

Then prepare the wheat as specified in 8.4.2 or 8.4.3, depending on the new moisture content.

## 9 Laboratory milling

### 9.1 General

The test mill (6.6) 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) 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.

NOTE The speed at which the products pass through the sieving drum can be set by adjusting the position of the blades on the beaters, i.e. two adjustable blades in the middle and at the end of the beater on the break side, and four blades at the end on the reduction side.

## 9.2 Milling procedure

### 9.2.1 Breaking

Switch on the device.

Set the feed rate to allow 800 g of conditioned wheat to pass through the mill in (5 ± 1) min.

Pour the conditioned wheat (8.4) into the mill feed hopper and, at the same time, start the timer to check the 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 (6.3), 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.

### 9.2.2 Reduction

Switch on the device.

Adjust the feed rate to allow the semolina produced in 9.2.1 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 % of the mass of conditioned wheat. (Round up the values: 47,4 becomes 47 and 47,5 becomes 48.)

When the mill stops, weigh (6.3), separately, the middlings and the reduction flour to the nearest 0,1 g.

Ensure that the milling ratio (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.

### 9.2.3 Flour homogenization

Pour the break and reduction flour into the blender flask (6.5.3).

Insert the stopper fitted with the worm screw (6.5.2) provided for use with flour into the flask and place the flask on the blender (6.5).

Mix for (20 ± 2) min.

Remove the worm screw (6.5.2) and replace it with the flask stopper. The flour is now ready for the Alveograph test.

### 9.2.4 Storage of the flour

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

## 9.3 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):

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

where

$H_f$ is the moisture content, as a percentage, of the flour obtained (determined in accordance with ISO 712 or ISO 12099);

$H_b$ is the moisture content, as a percentage, of the wheat test portion for milling before moistening (determined in accordance with ISO 712 or ISO 12099);

$M_f$ 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.

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

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

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

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

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.

NOTE Annex C provides an example of a milling sheet to follow all interesting results.

# 10 Preparation and Alveograph test

## 10.1 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, burette, tools, etc.) are clean.

Check that the *F*-register (see Figure 5) 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 (6.7.1) 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.

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 AlveoNG model 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.

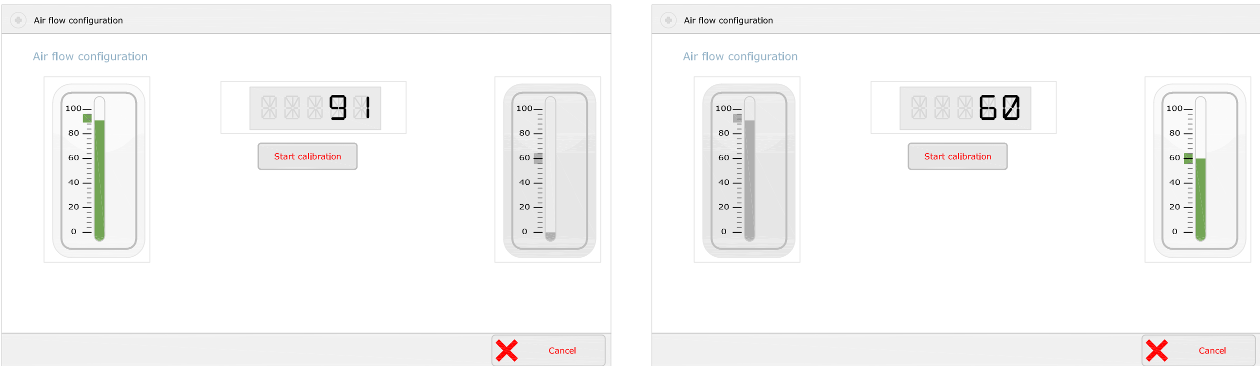
Check that the Alveograph plate is horizontal.

For the AlveoNG and AlveoPC models:

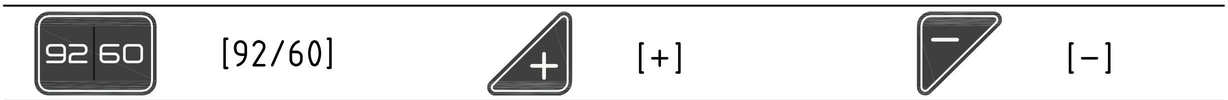
— check the air flow settings using the nozzle (see Table 1, footnote [a]) are creating the specified loss of pressure (see Figures 3 and 4 c)):

  — the air generator to a pressure corresponding to 92 $mmH_2O$ (12,3 kPa) on the recorder screen (see Figure 4 a));

  — the micrometer flow rate valve to a pressure corresponding to 60 $mmH_2O$ (8,0 kPa) on the recorder screen (see Figure 4 b)).




**a) 92 adjustment** **b) 60 adjustment**




**c) Command panel**

**Figure 4 — Measurement pressure setting**

## 10.2 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 in accordance with the method specified in ISO 712 or with an apparatus using near infrared spectroscopy whose performance has been demonstrated in accordance with ISO 12099. From Table 2, find the quantity of sodium chloride solution (5.1) to be used in 10.3 to prepare the dough.

For the AlveoNG and AlveoPC models, using Table 2, note the quantity of sodium chloride solution (5.1) to be used in 10.3 to prepare the dough.

For Alveolab model:

— Prepare the salt solution and place it in the tank provided for this purpose in the device.

— Check the level of the humidifier by opening the hatch of the dough collecting tray and top up if necessary. Use a pipette[4)] to avoid water overflowing into the compartment.

— Before the first try of the day, the upper and lower plates shall be oiled.

**Table 2 — Volume of sodium chloride solution to be added during kneading**

| Moisture content of the flour<br>% | Volume of solution to be added<br>ml | Moisture content of the flour<br>% | Volume of solution to be added<br>ml | Moisture content of the flour<br>% | Volume of solution to be added<br>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 | | |

NOTE The volume of sodium chloride solution (5.1), $V_{NaCl}$, 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 (5.1) and 100 g of flour with a moisture content of 15 %.

4) The pipette provided with the CHOPIN Technologies Alveolab is an example of suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

**Table 2** *(continued)*

| Moisture content of the flour<br>% | Volume of solution to be added<br>ml | Moisture content of the flour<br>% | Volume of solution to be added<br>ml | Moisture content of the flour<br>% | Volume of solution to be added<br>ml |
|---|---|---|---|---|---|
| 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 (5.1), $V_{NaCl}$, 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 (5.1) and 100 g of flour with a moisture content of 15 %.

## 10.3 Kneading

Place 250 ± 0,5 g of flour in the kneading machine (6.7.1). Secure the lid with the locking device.

At the same time, switch on the motor.

For the AlveoNG and AlveoPC models, use a burette (6.8) to deliver the appropriate quantity of sodium chloride solution (5.1) through the hole in the cover.

If the moisture content of the flour is less than 10,5 %, use the burette (6.8) to add a quantity of sodium chloride solution corresponding to a moisture content of 12 %, i.e. 138,2 ml. With a pipette (6.11), 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.

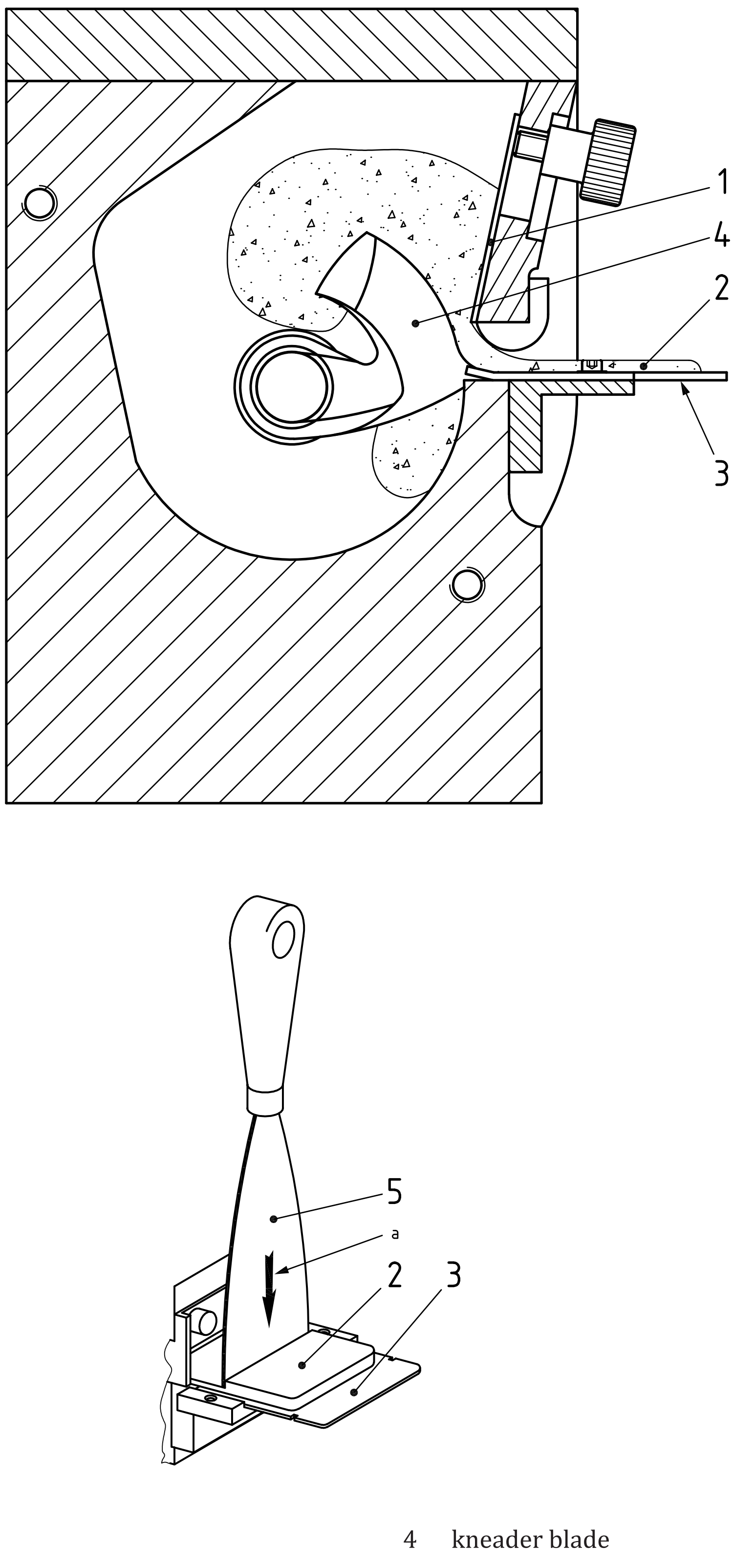
For the Alveolab model, when preparing the test, indicate the water content of the flour, send the instructions of the test to the device and start the water dosage. Once this dosage has been carried out by the device, follow the indications appearing on the screen and position the water injection nozzle on the tank.

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 5) 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.




**Key**

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

**Figure 5 — Dough extrusion and cutting**

### 10.4 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 (5.2) 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 5).

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 (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 (see Figure 6). 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.

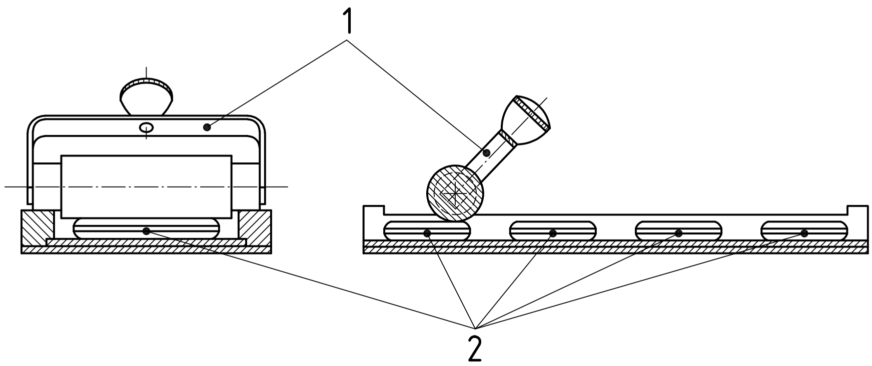
Sheet the four dough pieces using the previously oiled steel roller. Run the roller backwards and forwards along the rails 12 times in succession, six times in each direction (see Figure 6).

Using the cutter, cut a test piece from each strip of dough in one clean movement (see Figure 7). 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 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.

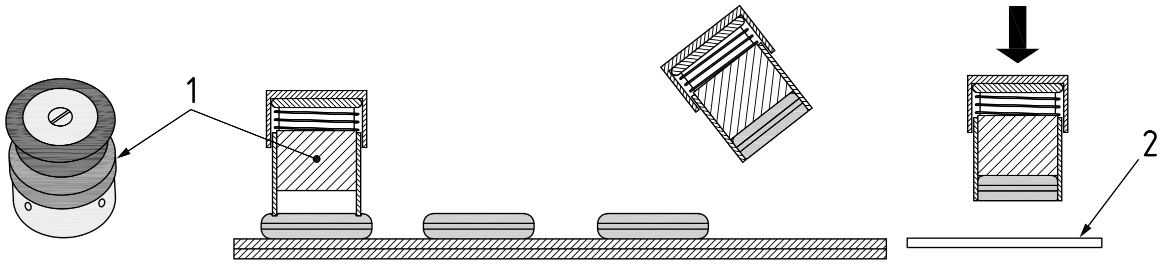



**Key**

1 steel roller

2 dough pieces

**Figure 6 — Laminating the dough pieces**




**Key**

1 cutter

2 resting plate

**Figure 7 — Dough pieces cutting and transfer to the plate**

## 10.5 Alveograph test

### 10.5.1 Initial preparation

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.

### 10.5.2 First operation: placing the patty on the lower plate

For the AlveoNG and AlveoPC models:

— Unscrew the knurled ring (see Figure 8, key item 1) and remove the pad (2).

— Unscrew the upper plate (5) using the handle (3) and reassemble until it reaches the level of the three guide studs (4).

— Turn the pad over and place it on the knurled ring.

— Oil the fixed plate (6) and spread the oil without hitting the bevel. Also oil the inside of the pad.

— Slide the dough piece (7) and centre it in relation to the plate, acting on its edge.

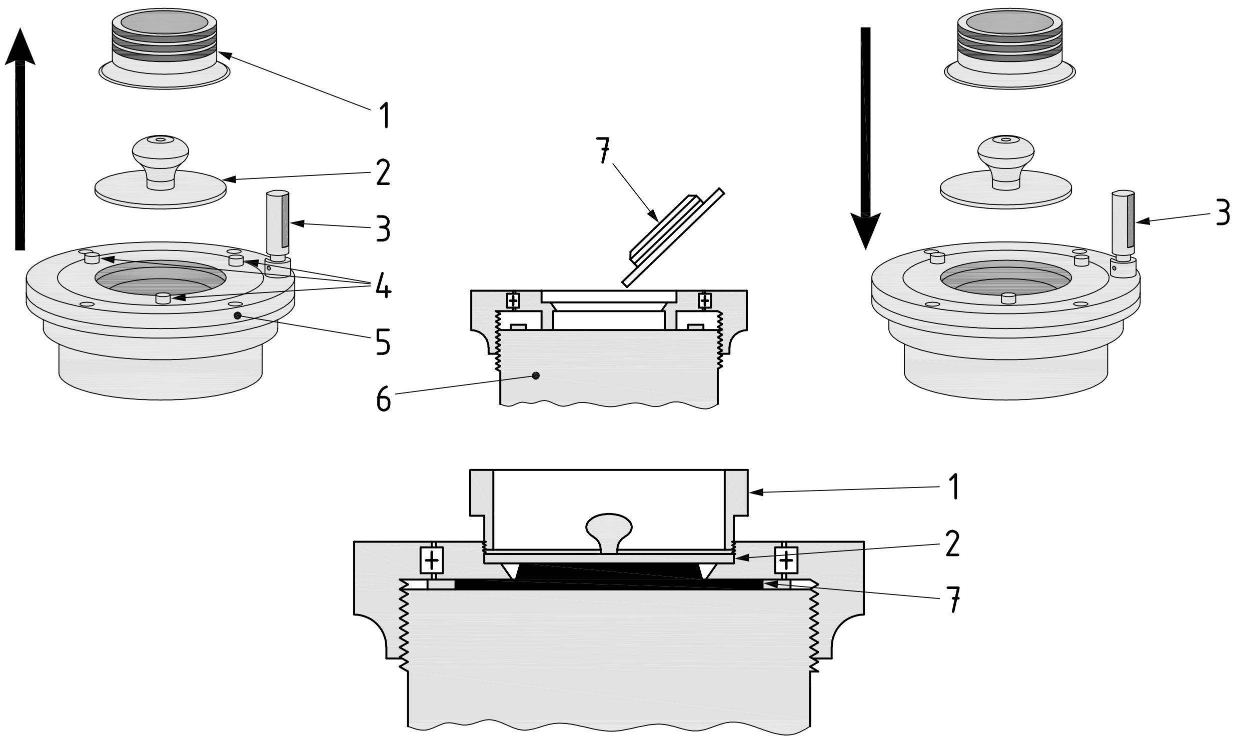
— Replace the pad and screw the knurled ring back to immobilize it.

— The handle for unscrewing the upper plate shall be lowered before carrying out the test (to do this, first pull the handle upwards).

— Flatten the dough piece by screwing the upper plate fitted with the pad blocked with the knurled ring in about 20 s (until it stops), without forcing.

— Remove the knurled ring and the pad, then put the handle down.




**Key**

1 knurled ring
2 pad
3 handle
4 guide studs
5 upper plate
6 fixed plate
7 dough piece

**Figure 8 — Placing the dough pieces on the Alveograph part (AlveoNG and AlveoPC)**

For the Alveolab model:

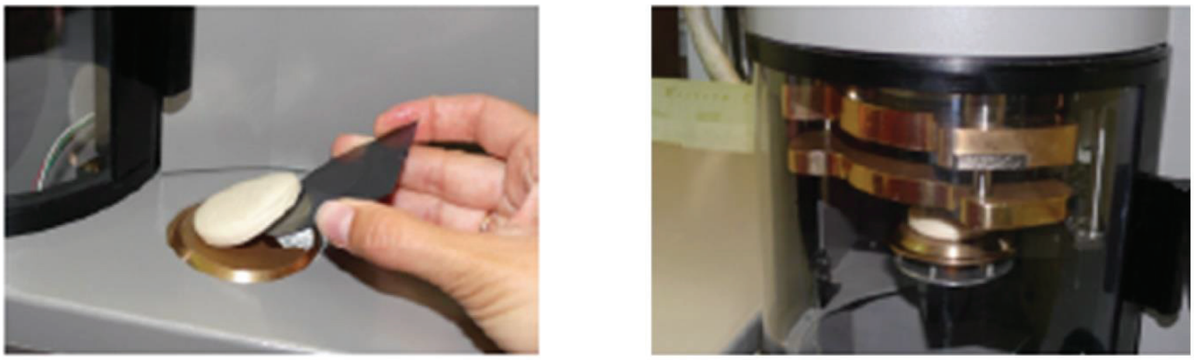
— Take out the first dough piece and place it on the previously oiled (1 to 2 drops) loading pad (see Figure 9 a)).

— Place a drop of oil (5.2) on the dough piece.

— Press the start test button.

The loading pad moves the dough piece up to the plate and blocks it at the test station (see Figure 9 b)).



a) Placing the dough piece on the loading pad

b) Dough piece automated transfer

**Figure 9 — Placing the dough pieces on the Alveograph part (Alveolab model)**

#### 10.5.3 Second operation: biaxial extension

For the AlveoNG and AlveoPC models:

— By pressing the [START/STOP TEST] key, the Alveograph starts up. This causes the swelling and the measurement to be taken into account by the Alveograph.

— As soon as the bubble breaks, stop the Alveograph [START/TEST STOP] key. The air supply is then stopped.

— Loosen the upper plate and completely disengage the dough.

— Repeat all the operations (placement of the dough piece and biaxial deformation) on the four remaining dough pieces.

For the Alveolab model:

— Once the dough is in place and crushed, the pad is automatically removed, and the device injects air into the dough while measuring the pressure in the bubble. The curve appears on the screen. The test ends when the bubble bursts, automatically detected by the device in real time. The plate loosens and a squeegee unhooks the dough and drops it in the recovery tank.

— If the dough remains suspended, pressing the [dough stop] key allows a new pass of the squeegee.

— Repeat these operations on the four remaining dough pieces.

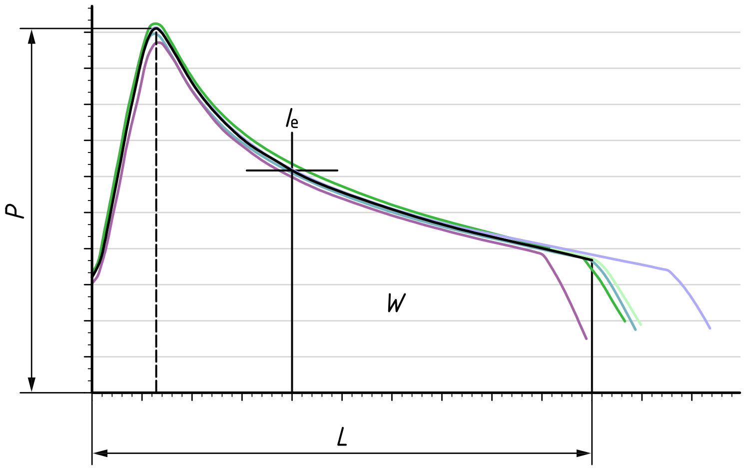
NOTE Annex G details the routine maintenance instructions for the Alveograph.

### 10.6 Expression of Alveograph test results

#### 10.6.1 General

The results are measured or calculated from the five curves obtained (see Figure 10). However, if one (and only one) of the curves deviates significantly from the other four, it should not be taken into account in the expression of results.

NOTE A result deviates significantly from the others if it has two clearly different parameters (often stiffness/extensibility) and/or if the operator knows that the dough concerned has undergone an unusual treatment (e.g. sticky, falling).




**Key**

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

$L$ mean abscissa at rupture points

$P$ maximum pressure parameter (mean of maximum ordinates times 1,1)

$W$ deformation work

**Figure 10 — Alveograph curve**

### 10.6.2 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, $K = 1,1$.

Express the *P* result, in millimetres, to the nearest integer.

### 10.6.3 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.

Express the *L* result, in millimetres, to the nearest integer.

### 10.6.4 Swelling index, *G*

The extensibility or the possibility of inflating the dough to form a bubble is expressed by the mean of the abscissa value at rupture, *L*, converted to the swelling index, *G*. 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):

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

Table D.1 gives a conversion table from *L* to *G*.

Express the *G* result, without unit, to the nearest one decimal place.

#### 10.6.5 Elasticity index, $I_e$

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.

Express the $I_e$ result, in percentage, to the nearest one decimal place.

#### 10.6.6 Curve configuration ratio, $P/L$

The term "curve configuration" is conventional.

Express the $P/L$ result, without unit, to the nearest two decimal places.

#### 10.6.7 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):

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

where $A$ is the area under the mean curve.

The coefficient 6,54 is valid for a constant air flow rate of 96 l/h.

Express the $W$ result to the nearest integer.

## 11 Precision

### 11.1 Interlaboratory tests

#### 11.1.1 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.

#### 11.1.2 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 in accordance with ISO 5725-2,[3] ISO 5725-3[4] and ISO 5725-6,[5] details of which are given in Annex F.

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

## 11.2 Repeatability limits

### 11.2.1 General

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 limits, *r*, are obtained by the formulae given in 11.2.2 and 11.2.3. To make them easier to use, practical application tables are given in Annexes E and F.

### 11.2.2 Commercial flour — Limits established by the interlaboratory test

For *W*:

$$r = (0{,}054\,1\ W - 1{,}571\,5) \times 2{,}77$$

For *P*:

$$r = (0{,}017\,3\ P + 0{,}310\,7) \times 2{,}77$$

For *L*:

$$r = (0{,}144\,9\ L - 7{,}083) \times 2{,}77$$

For *G*:

$$r = (0{,}121\,8\ G - 1{,}861\,7) \times 2{,}77$$

For *P*/*L*:

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

### 11.2.3 Flour obtained from laboratory milling

For *W*:

$$r = (0{,}034\,4\ W + 3{,}903\,8) \times 2{,}77$$

For *P*:

$$r = (0{,}026\,8\ P + 0{,}535) \times 2{,}77$$

For *L*:

$$r = (0{,}049\ L + 2{,}347\,1) \times 2{,}77$$

For *G*:

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

For *P*/*L*:

$$r = (0{,}121\,5\ P/L - 0{,}015\,4) \times 2{,}77$$

For $I_e$:

$$r = 0{,}89 \times 2{,}77 = 2{,}5$$

For the extraction rate:

$$r = 0{,}8 \times 2{,}77 = 2{,}3$$

## 11.3 Reproducibility limits

### 11.3.1 General

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 limits, $R$, are obtained by the formulae given in 11.3.2 and 11.3.3. To make them easier to use, practical application tables are given in Annexes E and F.

### 11.3.2 Commercial flour — Limits established by the proficiency tests

For $W$:

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

For $P$:

$$R = (0{,}045\ P + 0{,}15) \times 2{,}77$$

For $L$:

$$R = (0{,}06\ L + 1{,}81) \times 2{,}77$$

For $G$:

$$R = 0{,}8 \times 2{,}77 = 2{,}2$$

For $P/L$:

$$R = (0{,}121\ 4\ P/L - 0{,}018\ 4) \times 2{,}77$$

For $I_e$:

$$R = 2{,}0 \times 2{,}77 = 5{,}5$$

### 11.3.3 Flour obtained from laboratory milling

For $W$:

$$R = (0{,}053\,4\ W + 4{,}195\,1) \times 2{,}77$$

For $P$:

$$R = (0{,}063\,7\ P + 1{,}579\,9) \times 2{,}77$$

For $L$:

$$R = (0{,}099\,8\ L + 1{,}331\,1) \times 2{,}77$$

For $G$:

$$R = 1{,}25 \times 2{,}77 = 3{,}5$$

For $P/L$:

$$R = (0{,}210\,7\ P/L - 0{,}015\,4) \times 2{,}77$$

For $I_e$:

$$R = 2{,}12 \times 2{,}77 = 5{,}9$$

For the extraction rate:

$$R = 3{,}8 \times 2{,}77 = 10{,}5$$

## 11.4 Uncertainty

It is possible to evaluate measurement uncertainties using data obtained from studies carried out in accordance with ISO 5725-2.[3] The reproducibility standard deviation obtained during an interlaboratory test is a valid basis to assess measurement uncertainty because, by definition, uncertainty characterizes the dispersion of values that can be reasonably attributed to the parameter.

The calculated expanded standard uncertainty should be ≤ ± 2 reproducibility standard deviation.

# 12 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 document, i.e. ISO 27971:2023;

c) when laboratory milling is included in the test, all the 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 document, or regarded as optional, together with details of any incidents noted during the milling process and Alveograph test that can influence the test results;

f) the date of the test.

# Annex A
(informative)

# Characteristics of the mill[5] suitable for obtaining a laboratory milled flour

## 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.

5) The methods specified in this document are based on the use of the CHOPIN Technologies Chopin-Dubois CD1 mill, which is an example of suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

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 the sieves immediately if they are damaged, e.g. 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 six 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):

$$M_e = [M_b \times (H_s - H_b)] / (100 - H_s) \qquad \text{(B.1)}$$

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 8.4.4). | |
| 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 8.4.3). | |
| 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 | | |
| 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 document 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 8.4.4) | | 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 8.4.3) | | 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 8.4.2). | | 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 (%) | | $= (T_2/T_1) \times 100 =$ | | |

| | | |
|---|---|---|
| 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 $G$ | Length $L$ mm | Swelling $G$ | Length $L$ mm | Swelling $G$ | Length $L$ mm | Swelling $G$ | Length $L$ mm | Swelling $G$ |
|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

**Table D.1** *(continued)*

| **Length** *L* mm | **Swelling** *G* | **Length** *L* mm | **Swelling** *G* | **Length** *L* mm | **Swelling** *G* | **Length** *L* mm | **Swelling** *G* | **Length** *L* mm | **Swelling** *G* |
|---|---|---|---|---|---|---|---|---|---|
| 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

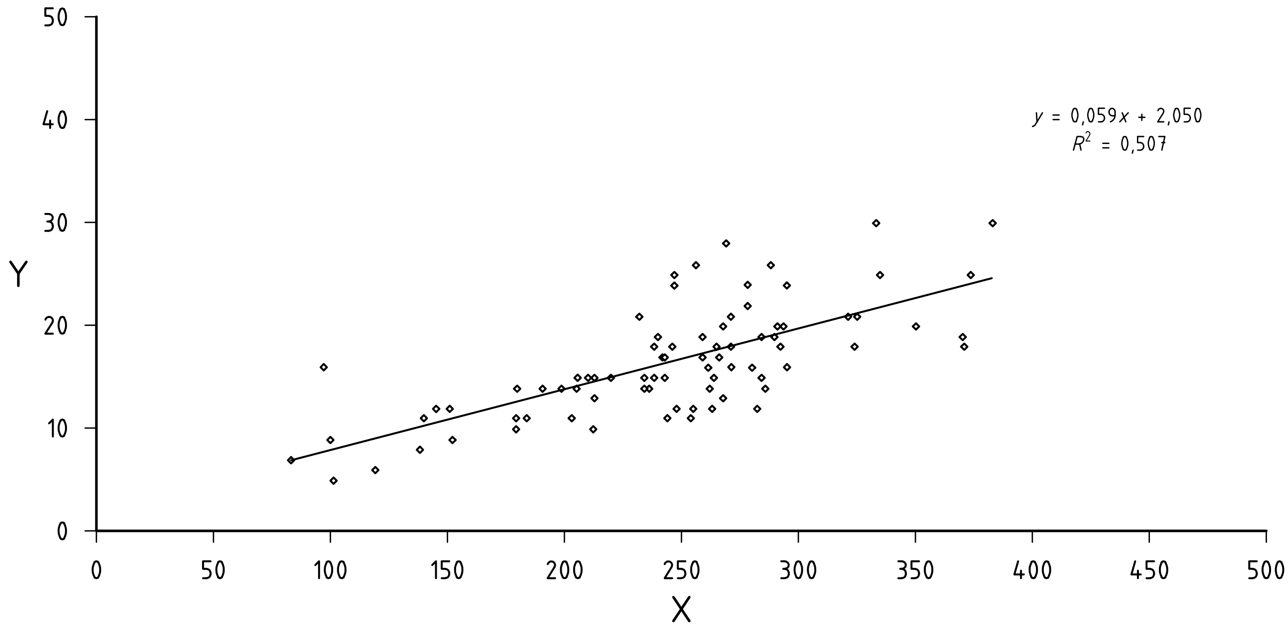
The repeatability and reproducibility limits of the method used for commercial flour were initially established within the context of an interlaboratory test in which six laboratories participated. The test was performed on three samples of flour and repeated four times on each sample.

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.

There were 14 to 29 laboratories, depending on the campaign, that 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.

Figures E.1, E.2, E.3 and E.5 show that the standard deviations of reproducibility, $s_R$, are dependent on the mean values of *W*, *P*, *L* and *P*/*L*, respectively.

$s_R$ has been considered as constant irrespective of the mean of *G* (see Figure E.3) and the mean of $I_e$ (see Figure E.6).




**Key**

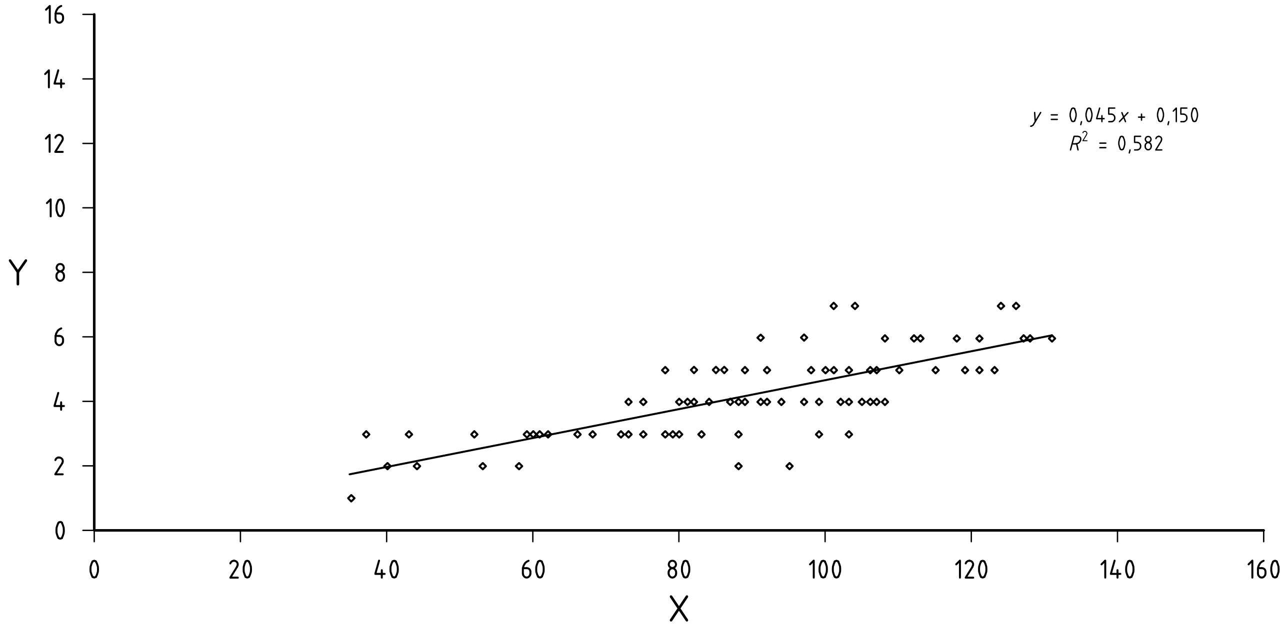
X W values

Y standard deviation of reproducibility ($s_R$)

*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)**




**Key**

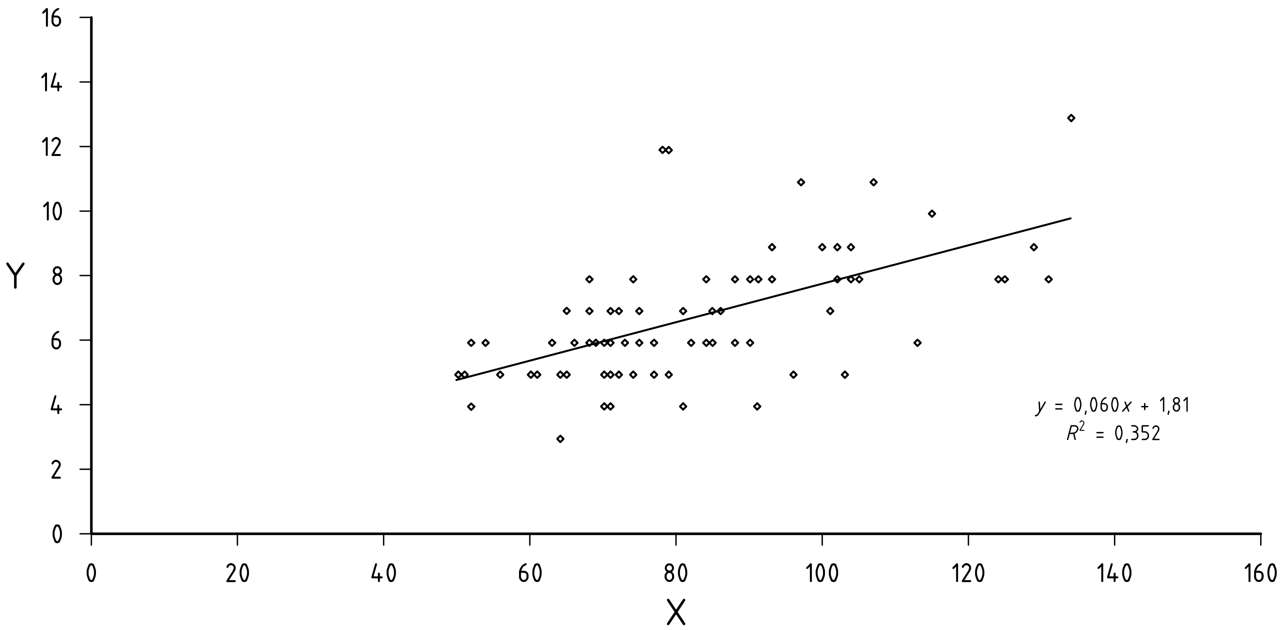
X P values

Y standard deviation of reproducibility ($s_R$)

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

$s_R$ $y$ = 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)**




**Key**

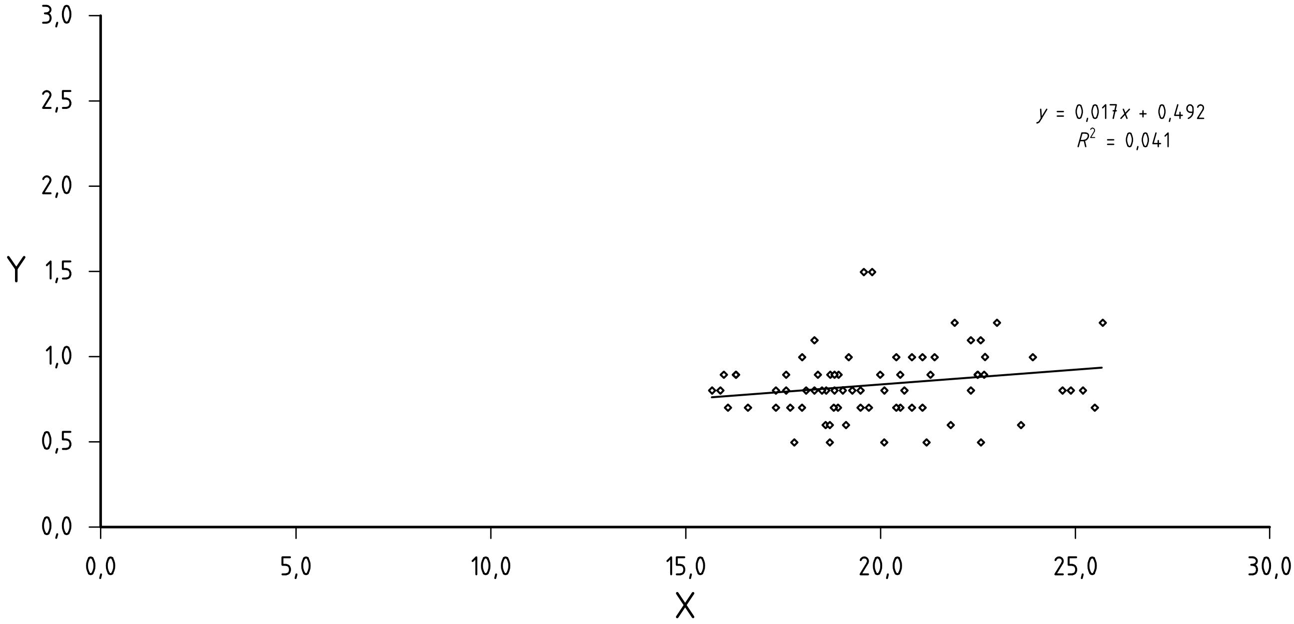
X L values

Y standard deviation of reproducibility ($s_R$)

*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)**




**Key**

X G values

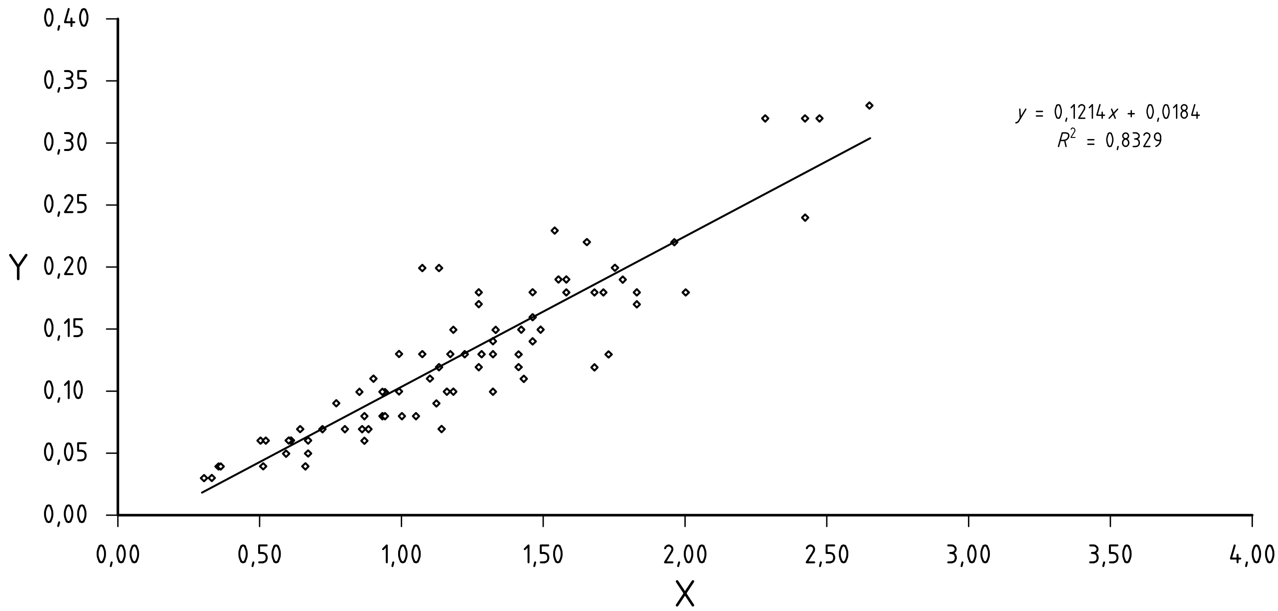
Y standard deviation of reproducibility ($s_R$)

*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)**




**Key**

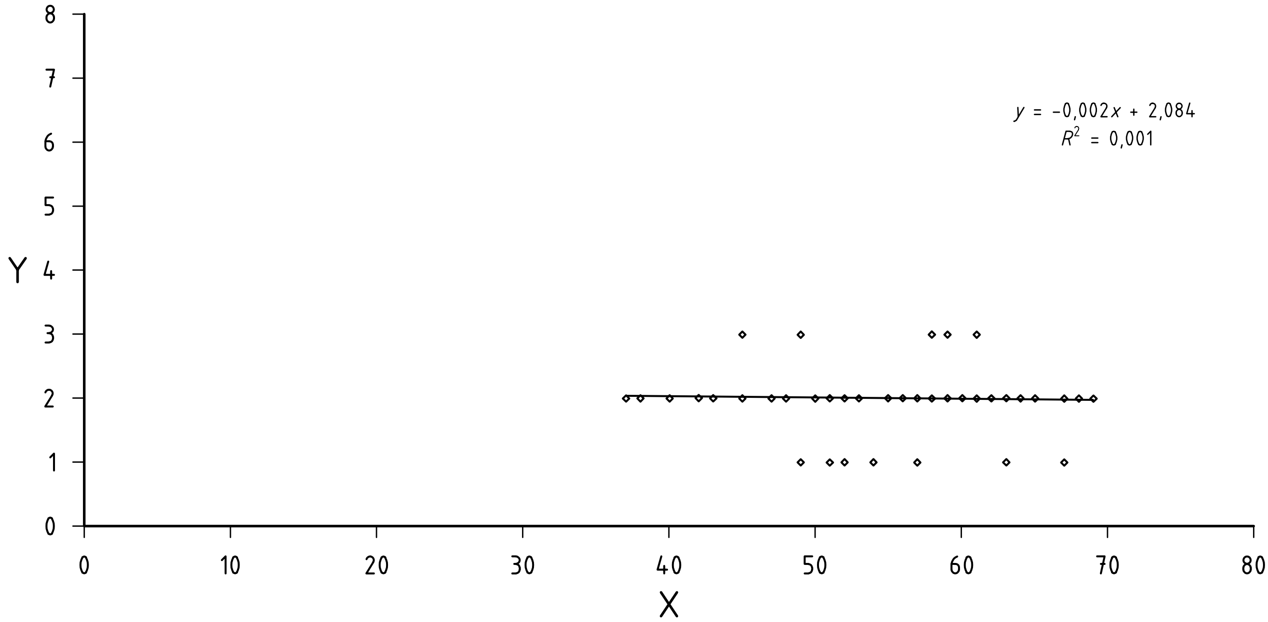
X P/L values

Y standard deviation of reproducibility ($s_R$)

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

$s_R$ *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)**




**Key**

X $I_e$ values

Y standard deviation of reproducibility ($s_R$)

$I_e$ mean of the control laboratories' $I_e$ values

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

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

Table E.1 summarizes the actual precision formulae for the method described in this document. Table E.2 summarizes the formulae accepted in previous versions of this document. Tables E.3 and E.4 provide a practical application of the formulae actually applicable for this method.

**Table E.1 — Summary of reproducibility formulae 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 | $0{,}12\ P/L - 0{,}02$ |
| $I_e$ | 37,0 to 69,0 | 2,0 |

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

| $W$ **Validity range: 190 to 415** $s_r$ = 0,054 1 $W$ − 1,571 5 | | $P$ **Validity range: 70 to 118** $s_r$ = 0,017 3 $P$ + 0,310 7 | | $L$ **Validity range: 78 to 98** $s_r$ = 0,144 9 $L$ − 7,083 | | $G$ **Validity range: 19,5 to 21,5** $s_r$ = 0,121 8 $G$ − 1,861 7 | | $P/L$ **Validity range: 0,92 to 1,28** $s_r$ = 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 $s_r$) | $G$ | **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 |
| 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 formulae for commercial flour (data from the proficiency tests)**

| *W*<br>**Validity range: 83 to 383**<br>$s_R$ = 0,059 W + 2,05 | | *P*<br>**Validity range: 35 to 131**<br>$s_R$ = 0,045 *P* + 0,15 | | *L*<br>**Validity range: 50 to 134**<br>$s_R$ = 0,06 *L* + 1,81 | | *G*<br>**Validity range: 15,7 to 25,7**<br>$s_R$ = 0,8 | | *P*/*L*<br>**Validity range: 0,30 to 2,65**<br>$s_R$ = 0,121 *P*/*L* – 0,018 | | $l_e$<br>**Validity range: 37,0 to 69,0**<br>$s_R$ = 2,0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *W*<br>$10^{-4}$ J | **Reproducibility limit**<br>$R = s_R \times 2,77$ | *P*<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | *L*<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | *G* | **Reproducibility limit**<br>$R = s_R \times 2,77$ | *P*/*L* | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $l_e$<br>% | **Reproducibility limit**<br>$R = s_R \times 2,77$ |
| 80 | 19 | 35 | 5 | 50 | 13 | 15,6 | 2,2 | 0,30 | 0,05 | 61,7 | 5,54 |
| 85 | 20 | 37 | 5 | 52 | 14 | 15,8 | 2,2 | 0,35 | 0,07 | 62,0 | 5,54 |
| 90 | 20 | 39 | 5 | 54 | 14 | 16,0 | 2,2 | 0,40 | 0,08 | 62,2 | 5,54 |
| 95 | 21 | 41 | 6 | 56 | 14 | 16,2 | 2,2 | 0,45 | 0,10 | 62,5 | 5,54 |
| 100 | 22 | 43 | 6 | 58 | 15 | 16,4 | 2,2 | 0,50 | 0,12 | 62,7 | 5,54 |
| 105 | 23 | 45 | 6 | 60 | 15 | 16,6 | 2,2 | 0,55 | 0,13 | 63,0 | 5,54 |
| 110 | 24 | 47 | 6 | 62 | 15 | 16,8 | 2,2 | 0,60 | 0,15 | 63,2 | 5,54 |
| 115 | 24 | 49 | 7 | 64 | 16 | 17,0 | 2,2 | 0,65 | 0,17 | 63,4 | 5,54 |
| 120 | 25 | 51 | 7 | 66 | 16 | 17,2 | 2,2 | 0,70 | 0,18 | 63,7 | 5,54 |
| 125 | 26 | 53 | 7 | 68 | 16 | 17,4 | 2,2 | 0,75 | 0,20 | 64,0 | 5,54 |
| 130 | 27 | 55 | 7 | 70 | 17 | 17,6 | 2,2 | 0,80 | 0,22 | 64,2 | 5,54 |
| 135 | 28 | 57 | 8 | 72 | 17 | 17,8 | 2,2 | 0,85 | 0,24 | 64,5 | 5,54 |
| 140 | 29 | 59 | 8 | 74 | 17 | 18,0 | 2,2 | 0,90 | 0,25 | 64,7 | 5,54 |
| 145 | 29 | 61 | 8 | 76 | 18 | 18,2 | 2,2 | 0,95 | 0,27 | 65,0 | 5,54 |
| 150 | 30 | 63 | 8 | 78 | 18 | 18,4 | 2,2 | 1,00 | 0,29 | 65,2 | 5,54 |
| 155 | 31 | 65 | 9 | 80 | 18 | 18,6 | 2,2 | 1,05 | 0,30 | 65,5 | 5,54 |
| 160 | 32 | 67 | 9 | 82 | 19 | 18,8 | 2,2 | 1,10 | 0,32 | 65,7 | 5,54 |
| 165 | 33 | 69 | 9 | 84 | 19 | 19,0 | 2,2 | 1,15 | 0,34 | 66,0 | 5,54 |
| 170 | 33 | 71 | 9 | 86 | 19 | 19,2 | 2,2 | 1,20 | 0,35 | 66,2 | 5,54 |
| 175 | 34 | 73 | 10 | 88 | 20 | 19,4 | 2,2 | 1,25 | 0,37 | 66,5 | 5,54 |
| 180 | 35 | 75 | 10 | 90 | 20 | 19,6 | 2,2 | 1,30 | 0,39 | 66,7 | 5,54 |
| 185 | 36 | 77 | 10 | 92 | 20 | 19,8 | 2,2 | 1,35 | 0,40 | 66,9 | 5,54 |
| 190 | 37 | 79 | 10 | 94 | 21 | 20,0 | 2,2 | 1,40 | 0,42 | 67,2 | 5,54 |
| 195 | 38 | 81 | 11 | 96 | 21 | 20,2 | 2,2 | 1,45 | 0,44 | 67,5 | 5,54 |

**Table E.4** *(continued)*

| $W$<br>**Validity range: 83 to 383**<br>$s_R$ = 0,059 W + 2,05 | | $P$<br>**Validity range: 35 to 131**<br>$s_R$ = 0,045 $P$ + 0,15 | | $L$<br>**Validity range: 50 to 134**<br>$s_R$ = 0,06 $L$ + 1,81 | | $G$<br>**Validity range: 15,7 to 25,7**<br>$s_R$ = 0,8 | | $P/L$<br>**Validity range: 0,30 to 2,65**<br>$s_R$ = 0,121 $P/L$ – 0,018 | | $l_e$<br>**Validity range: 37,0 to 69,0**<br>$s_R$ = 2,0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $W$<br>$10^{-4}$ J | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $P$<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $L$<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $G$ | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $P/L$ | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $l_e$<br>% | **Reproducibility limit**<br>$R = s_R \times 2,77$ |
| 200 | 38 | 83 | 11 | 98 | 21 | 20,4 | 2,2 | 1,50 | 0,45 | 67,7 | 5,54 |
| 205 | 39 | 85 | 11 | 100 | 22 | 20,6 | 2,2 | 1,55 | 0,47 | 68,0 | 5,54 |
| 210 | 40 | 87 | 11 | 102 | 22 | 20,8 | 2,2 | 1,60 | 0,49 | 68,2 | 5,54 |
| 215 | 41 | 89 | 12 | 104 | 22 | 21,0 | 2,2 | 1,65 | 0,50 | 68,5 | 5,54 |
| 220 | 42 | 91 | 12 | 106 | 23 | 21,2 | 2,2 | 1,70 | 0,52 | 68,7 | 5,54 |
| 225 | 42 | 93 | 12 | 108 | 23 | 21,4 | 2,2 | 1,75 | 0,54 | 69,0 | 5,54 |
| 230 | 43 | 95 | 12 | 110 | 23 | 21,6 | 2,2 | 1,80 | 0,55 | 69,2 | 5,54 |
| 235 | 44 | 97 | 13 | 112 | 24 | 21,8 | 2,2 | 1,85 | 0,57 | 69,5 | 5,54 |
| 240 | 45 | 99 | 13 | 114 | 24 | 22,0 | 2,2 | 1,90 | 0,59 | 69,7 | 5,54 |
| 245 | 46 | 101 | 13 | 116 | 24 | 22,2 | 2,2 | 1,95 | 0,60 | 70,0 | 5,54 |
| 250 | 47 | 103 | 13 | 118 | 25 | 22,4 | 2,2 | 2,00 | 0,62 | 70,2 | 5,54 |
| 255 | 47 | 105 | 14 | 120 | 25 | 22,6 | 2,2 | 2,05 | 0,64 | 70,5 | 5,54 |
| 260 | 48 | 107 | 14 | 122 | 25 | 22,8 | 2,2 | 2,10 | 0,65 | 70,7 | 5,54 |
| 265 | 49 | 109 | 14 | 124 | 26 | 23,0 | 2,2 | 2,15 | 0,67 | 71,0 | 5,54 |
| 270 | 50 | 111 | 14 | 126 | 26 | 23,2 | 2,2 | 2,20 | 0,69 | 71,2 | 5,54 |
| 275 | 51 | 113 | 15 | 128 | 26 | 23,4 | 2,2 | 2,25 | 0,70 | 71,5 | 5,54 |
| 280 | 51 | 115 | 15 | 130 | 27 | 23,6 | 2,2 | 2,30 | 0,72 | 71,7 | 5,54 |
| 285 | 52 | 117 | 15 | 132 | 27 | 23,8 | 2,2 | 2,35 | 0,74 | | |
| 290 | 53 | 119 | 15 | 134 | 27 | 24,0 | 2,2 | 2,40 | 0,75 | | |
| 295 | 54 | 121 | 15 | | | 24,2 | 2,2 | 2,45 | 0,77 | | |
| 300 | 55 | 123 | 16 | | | 24,4 | 2,2 | 2,50 | 0,79 | | |
| 305 | 56 | 125 | 16 | | | 24,6 | 2,2 | 2,55 | 0,80 | | |
| 310 | 56 | 127 | 16 | | | 24,8 | 2,2 | 2,60 | 0,82 | | |
| 315 | 57 | 129 | 16 | | | 25,0 | 2,2 | 2,65 | 0,84 | | |

**Table E.4** *(continued)*

| $W$<br>**Validity range: 83 to 383**<br>$s_R$ = 0,059 W + 2,05 | | $P$<br>**Validity range: 35 to 131**<br>$s_R$ = 0,045 $P$ + 0,15 | | $L$<br>**Validity range: 50 to 134**<br>$s_R$ = 0,06 $L$ + 1,81 | | $G$<br>**Validity range: 15,7 to 25,7**<br>$s_R$ = 0,8 | | $P/L$<br>**Validity range: 0,30 to 2,65**<br>$s_R$ = 0,121 $P/L$ − 0,018 | | $l_e$<br>**Validity range: 37,0 to 69,0**<br>$s_R$ = 2,0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $W$<br>$10^{-4}$ J | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $P$<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $L$<br>mm | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $G$ | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $P/L$ | **Reproducibility limit**<br>$R = s_R \times 2,77$ | $l_e$<br>% | **Reproducibility limit**<br>$R = s_R \times 2,77$ |
| 320 | 58 | 131 | 17 | | | 25,2 | 2,2 | 2,70 | 0,86 | | |
| 325 | 59 | | | | | 25,4 | 2,2 | | | | |
| 330 | 60 | | | | | 25,6 | 2,2 | | | | |
| 335 | 60 | | | | | 25,8 | 2,2 | | | | |
| 340 | 61 | | | | | | | | | | |
| 345 | 62 | | | | | | | | | | |
| 350 | 63 | | | | | | | | | | |
| 355 | 64 | | | | | | | | | | |
| 360 | 65 | | | | | | | | | | |
| 365 | 65 | | | | | | | | | | |
| 370 | 66 | | | | | | | | | | |
| 375 | 67 | | | | | | | | | | |
| 380 | 68 | | | | | | | | | | |
| 383 | 68 | | | | | | | | | | |

# 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 in accordance with ISO 5725-2,[3] ISO 5725-3[4] and ISO 5725-6[5].

Ten laboratories participated in the first test campaign and twelve 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 given in Tables F.1 to F.9.

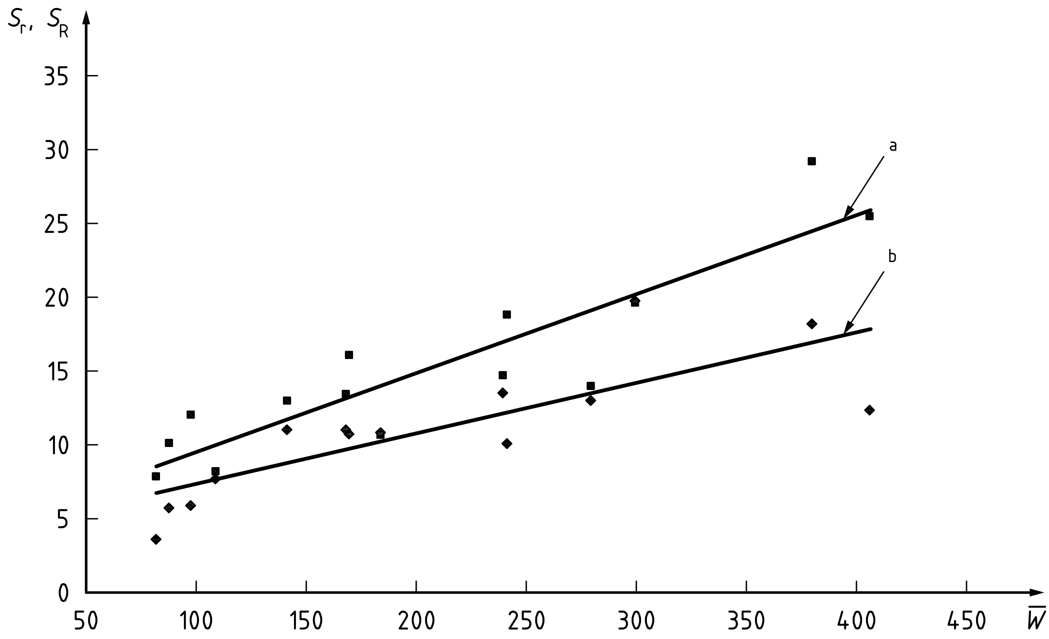
Figures F.1, F.2, F.4 and F.5 show that the standard deviations of repeatability, $s_r$, and reproducibility, $s_R$, are dependent on the mean values of $W$, $P$, $L$ and $P/L$, respectively.

$s_r$ and $s_R$ had been considered as constant irrespective of the mean of $G$ (see Figure F.3) and the mean of extraction rate (see Figure F.7), and based on the conclusion of the two interlaboratory tests.

Figure F.6 shows that $s_r$ and $s_R$ are considered to be constant irrespective of the mean value of $l_e$.

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **10** | **7** | **8** | **5** | **1** | **2** | **12** | **3** | **11** | **4** | **14** | **9** | **13** | **6** |
| No. of 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 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 $W$

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

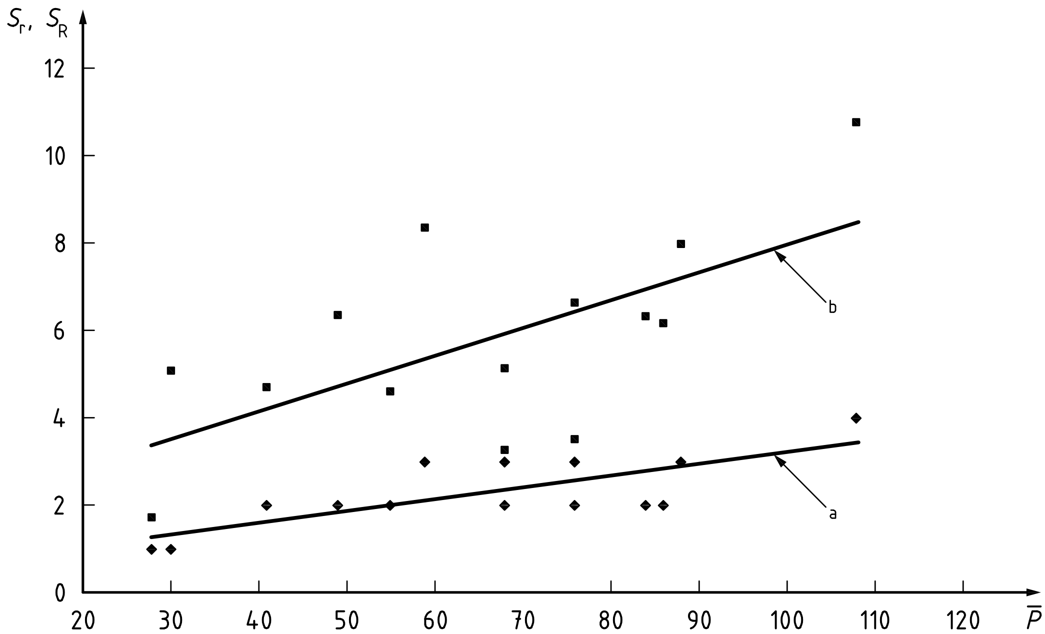
b $s_r$; $y = 0{,}034\ 4\ x + 3{,}903\ 8$; $R^2 = 0{,}655$ (correlation coefficient).

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

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5** | **8** | **10** | **12** | **4** | **7** | **1** | **2** | **3** | **13** | **14** | **6** | **11** | **9** |
| No. of laboratories | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 |
| Mean, $\overline{W}$ | 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 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 $P$

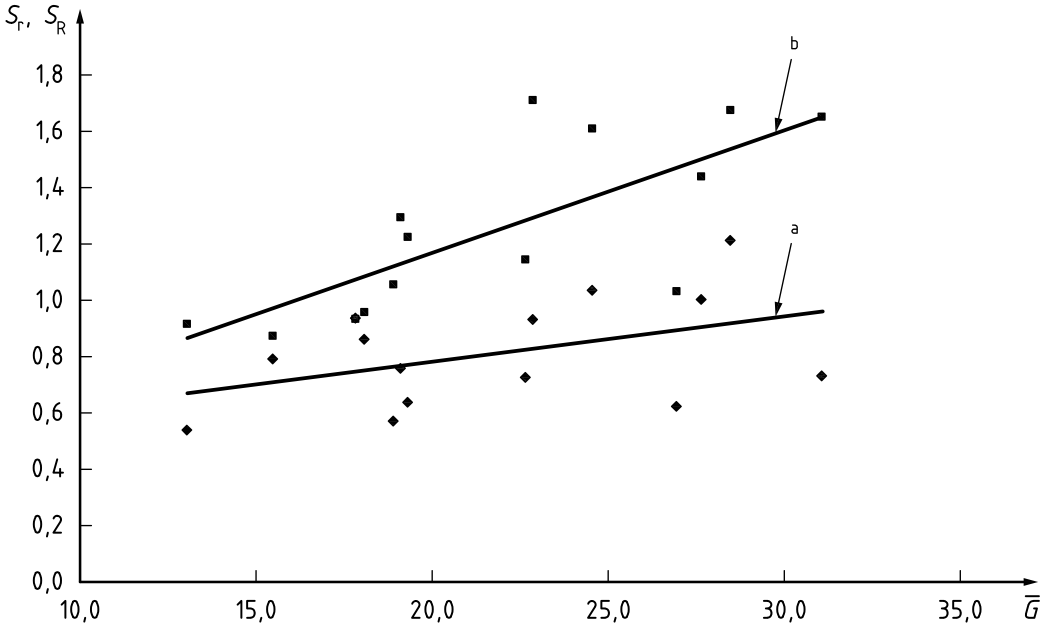
a $s_r$; $y$ = 0,026 8 $x$ + 0,535; $R^2$ = 0,565 8 (correlation coefficient).

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***

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **7** | **1** | **3** | **2** | **11** | **9** | **10** | **14** | **8** | **12** | **6** | **5** | **13** | **4** |
| No. of laboratories | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 |
| Mean, $\overline{W}$ | 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 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 |
| $R$ | 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**

$\overline{G}$ mean of $G$

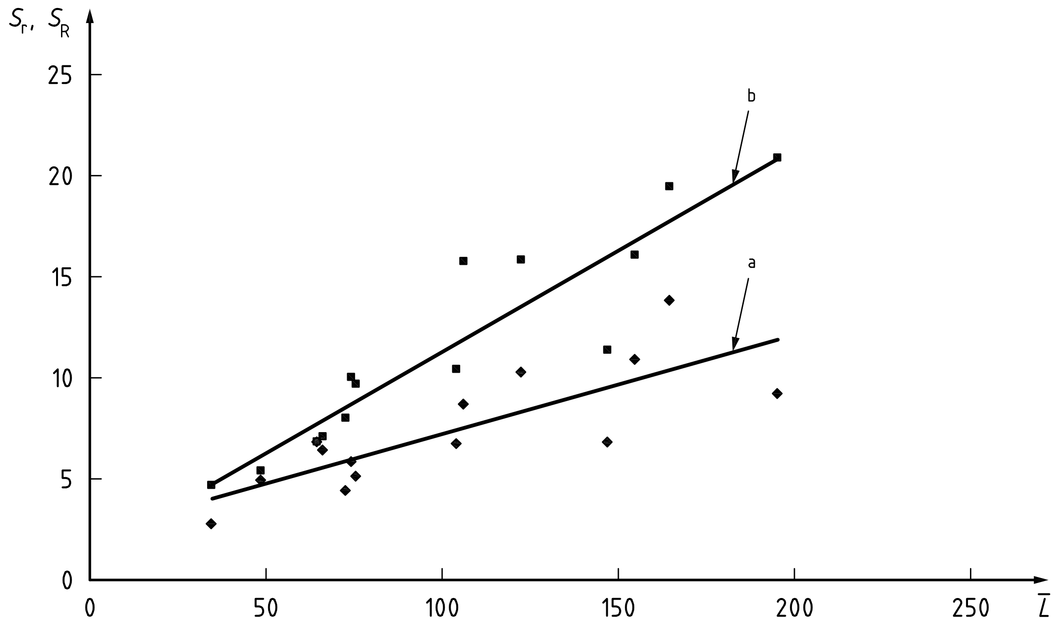
[a] $s_r$; $y = 0{,}016\ x + 0{,}462\ 6$; $R^2 = 0{,}19$ (correlation coefficient).

[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***

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **7** | **1** | **3** | **2** | **11** | **9** | **10** | **14** | **8** | **12** | **6** | **5** | **13** | **4** |
| No. of laboratories | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 |
| Mean, $\overline{W}$ | 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 14 | 11 | 11 | 11 | 11 | 13 | 13 | 10 | 15 | 13 | 8 | 10 | 12 | 11 |
| $R$ | 13 | 15 | 19 | 20 | 22 | 28 | 27 | 29 | 44 | 44 | 32 | 44 | 54 | 58 |




**Key**

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

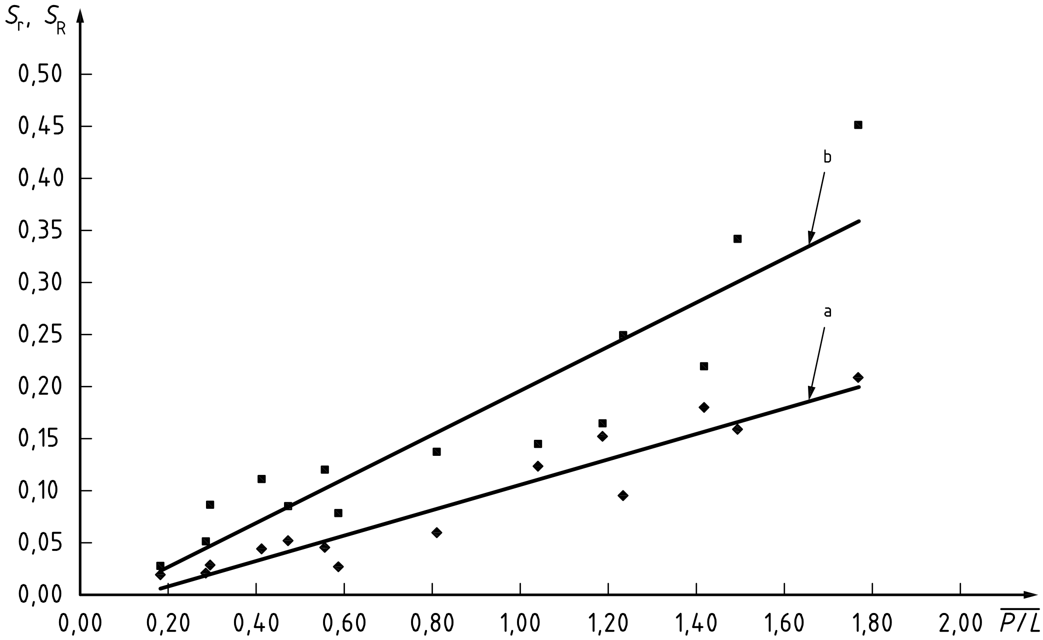
a $s_r$; $y = 0{,}049\ x + 2{,}347\ 1$; $R^2 = 0{,}644$ (correlation coefficient).

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***

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **5** | **4** | **8** | **12** | **13** | **10** | **6** | **14** | **2** | **3** | **11** | **1** | **9** | **7** |
| No. of laboratories | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 10 |
| Mean, $\overline{W}$ | 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 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 $P/L$

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

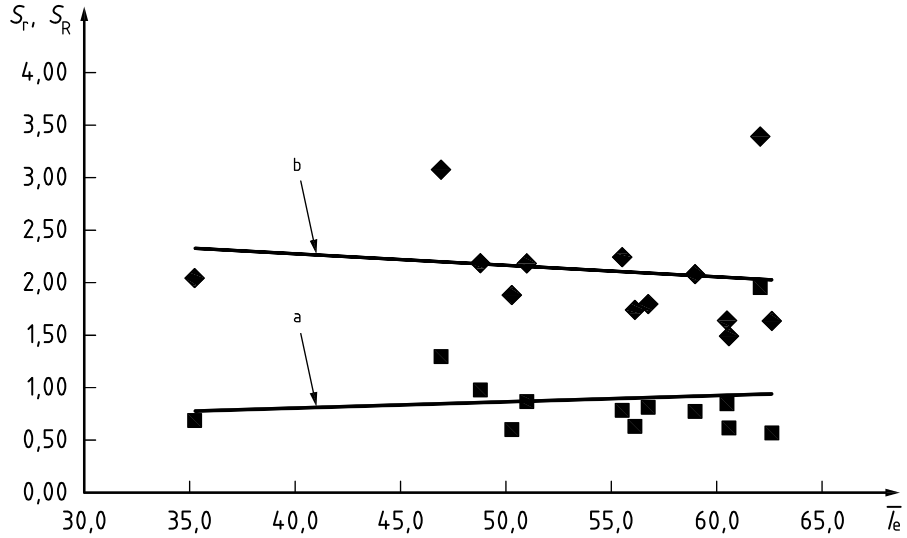
b $s_R$; $y = 0{,}210\,7\,x - 0{,}015\,4$; $R^2 = 0{,}846\,4$ (correlation coefficient).

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

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

| Parameter | Wheat | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 4 | 5 | 4 | 6 | 2 | 2 | 8 | 3 | 5 | 7 | 3 | 1 | 6 |
| No. of laboratories | — | 10 | 10 | 9 | 10 | 10 | 10 | 9 | 9 | 10 | 9 | 10 | 8 | 10 |
| Mean, $\overline{W}$ | — | 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 |
| $C_{V,r}$, % | — | 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 |
| $C_{V,R}$, % | — | 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 $I_e$

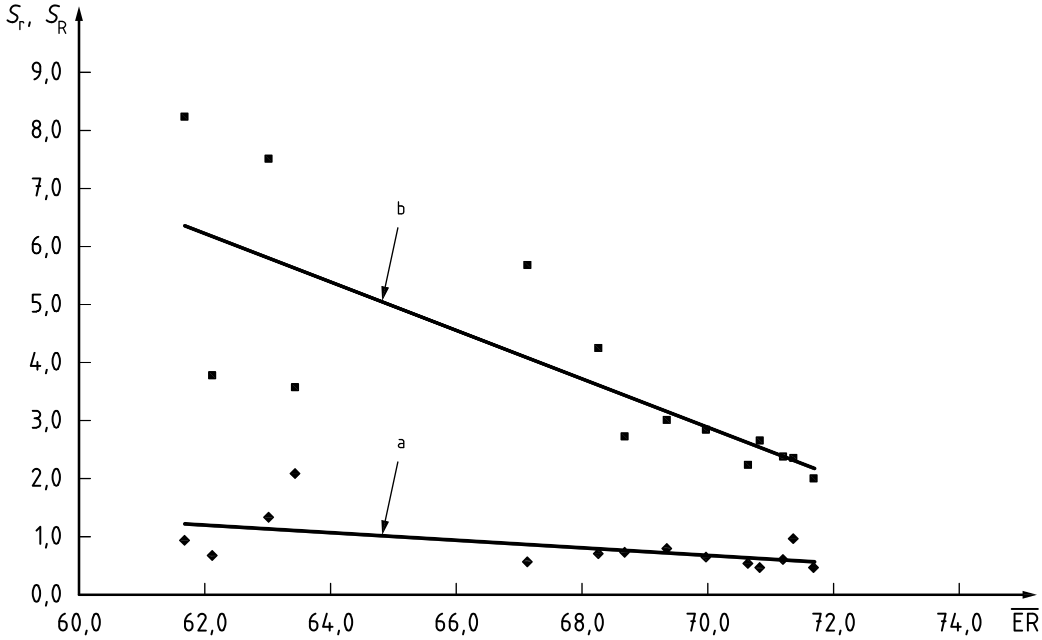
a $s_r$; $y = 0{,}005\ 4\ x + 0{,}593\ 7$; $R^2 = 0{,}012\ 4$ (correlation coefficient).

b $s_R$; $y = -0{,}011\ 2\ x + 2{,}725\ 2$; $R^2 = 0{,}023\ 7$ (correlation coefficient).

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

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

| Parameter | Wheat | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **7** | **14** | **11** | **10** | **12** | **8** | **13** | **2** | **9** | **6** | **3** | **4** | **5** | **1** |
| No. of laboratories | 9 | 8 | 10 | 8 | 9 | 10 | 9 | 10 | 9 | 10 | 9 | 10 | 10 | 10 |
| Mean, $\overline{W}$ | 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 |
| $C_{V,r}$, % | 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 |
| $C_{V,R}$, % | 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**

$\overline{\mathrm{ER}}$ mean of ER

[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**

## Table F.8 — Practical application of repeatability formulae for laboratory milled flour

| *W* | | *P* | | *L* | | *G* | | *P/L* | | $I_e$ | | **Extraction rate,** ER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Validity range: 82 to 406** | | **Validity range: 28 to 108** | | **Validity range: 35 to 195** | | **Validity range: 13,1 to 31,1** | | **Validity range: 0,18 to 1,77** | | **Validity range: 35,3 to 62,6** | | **Validity range: 61,7 to 71,7** | |
| $s_r = 0{,}034\,4\,W + 3{,}903\,8$ | | $s_r = 0{,}026\,8\,P + 0{,}535$ | | $s_r = 0{,}049\,L + 2{,}347\,1$ | | $s_r = 0{,}81$ | | $s_r = 0{,}121\,5(P/L) - 0{,}015\,4$ | | $s_r = 0{,}89$ | | $s_r = 0{,}8$ | |
| *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* — | **Repeatability limit** ($r = 2{,}77\,s_r$) | *P/L* — | **Repeatability limit** ($r = 2{,}77\,s_r$) | $I_e$ % | **Repeatability limit** ($r = 2{,}77\,s_r$) | ER % | **Repeatability limit** ($r = 2{,}77\,s_r$) |
| 80 | 18 | 28 | 4 | 35 | 11 | 13,1 | 2,2 | 0,18 | 0,02 | 35,5 | 2,5 | 61,7 | 2,3 |
| 90 | 19 | 30 | 4 | 40 | 12 | 13,6 | 2,2 | 0,20 | 0,02 | 36,5 | 2,5 | 62,0 | 2,3 |
| 100 | 20 | 32 | 4 | 45 | 13 | 14,1 | 2,2 | 0,25 | 0,04 | 37,5 | 2,5 | 62,2 | 2,3 |
| 110 | 21 | 34 | 4 | 50 | 13 | 14,6 | 2,2 | 0,30 | 0,06 | 38,5 | 2,5 | 62,4 | 2,3 |
| 120 | 22 | 36 | 4 | 55 | 14 | 15,1 | 2,2 | 0,35 | 0,08 | 39,5 | 2,5 | 62,7 | 2,3 |
| 130 | 23 | 38 | 4 | 60 | 15 | 15,6 | 2,2 | 0,40 | 0,09 | 40,5 | 2,5 | 63,0 | 2,3 |
| 140 | 24 | 40 | 4 | 65 | 15 | 16,1 | 2,2 | 0,45 | 0,11 | 41,5 | 2,5 | 63,2 | 2,3 |
| 150 | 25 | 42 | 5 | 70 | 16 | 16,6 | 2,2 | 0,50 | 0,13 | 42,5 | 2,5 | 63,4 | 2,3 |
| 160 | 26 | 44 | 5 | 75 | 17 | 17,1 | 2,2 | 0,55 | 0,14 | 43,5 | 2,5 | 63,7 | 2,3 |
| 170 | 27 | 46 | 5 | 80 | 17 | 17,6 | 2,2 | 0,60 | 0,16 | 44,5 | 2,5 | 64,0 | 2,3 |
| 180 | 28 | 48 | 5 | 85 | 18 | 18,1 | 2,2 | 0,65 | 0,18 | 45,5 | 2,5 | 64,2 | 2,3 |
| 190 | 29 | 50 | 5 | 90 | 19 | 18,6 | 2,2 | 0,70 | 0,19 | 46,5 | 2,5 | 64,4 | 2,3 |
| 200 | 30 | 52 | 5 | 95 | 19 | 19,1 | 2,2 | 0,75 | 0,21 | 47,5 | 2,5 | 64,7 | 2,3 |
| 210 | 31 | 54 | 5 | 100 | 20 | 19,6 | 2,2 | 0,80 | 0,23 | 48,5 | 2,5 | 65,0 | 2,3 |
| 220 | 32 | 56 | 6 | 105 | 21 | 20,1 | 2,2 | 0,85 | 0,24 | 49,5 | 2,5 | 65,2 | 2,3 |
| 230 | 33 | 58 | 6 | 110 | 21 | 20,6 | 2,2 | 0,90 | 0,26 | 50,5 | 2,5 | 65,4 | 2,3 |
| 240 | 34 | 60 | 6 | 115 | 22 | 21,1 | 2,2 | 0,95 | 0,28 | 51,5 | 2,5 | 65,7 | 2,3 |
| 250 | 35 | 62 | 6 | 120 | 23 | 21,6 | 2,2 | 1,00 | 0,29 | 52,5 | 2,5 | 66,0 | 2,3 |
| 260 | 36 | 64 | 6 | 125 | 23 | 22,1 | 2,2 | 1,05 | 0,31 | 53,5 | 2,5 | 66,2 | 2,3 |
| 270 | 37 | 66 | 6 | 130 | 24 | 22,6 | 2,2 | 1,10 | 0,33 | 54,5 | 2,5 | 66,4 | 2,3 |
| 280 | 37 | 68 | 7 | 135 | 25 | 23,1 | 2,2 | 1,15 | 0,34 | 55,5 | 2,5 | 66,7 | 2,3 |
| 290 | 38 | 70 | 7 | 140 | 26 | 23,6 | 2,2 | 1,20 | 0,36 | 56,5 | 2,5 | 67,0 | 2,3 |
| 300 | 39 | 72 | 7 | 145 | 26 | 24,1 | 2,2 | 1,25 | 0,38 | 57,5 | 2,5 | 67,2 | 2,3 |
| 310 | 40 | 74 | 7 | 150 | 27 | 24,6 | 2,2 | 1,30 | 0,39 | 58,5 | 2,5 | 67,4 | 2,3 |
| 320 | 41 | 76 | 7 | 155 | 28 | 25,1 | 2,2 | 1,35 | 0,41 | 59,5 | 2,5 | 67,7 | 2,3 |
| 330 | 42 | 78 | 7 | 160 | 28 | 25,6 | 2,2 | 1,40 | 0,43 | 60,5 | 2,5 | 68,0 | 2,3 |
| 340 | 43 | 80 | 7 | 165 | 29 | 26,1 | 2,2 | 1,45 | 0,45 | 61,5 | 2,5 | 68,2 | 2,3 |

**Table F.8** *(continued)*

| *W* | | *P* | | *L* | | *G* | | *P/L* | | $I_e$ | | **Extraction rate,** ER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Validity range: 82 to 406** | | **Validity range: 28 to 108** | | **Validity range: 35 to 195** | | **Validity range: 13,1 to 31,1** | | **Validity range: 0,18 to 1,77** | | **Validity range: 35,3 to 62,6** | | **Validity range: 61,7 to 71,7** | |
| $s_r$ = 0,034 4 *W* + 3,903 8 | | $s_r$ = 0,026 8 *P* + 0,535 | | $s_r$ = 0,049 *L* + 2,347 1 | | $s_r$ = 0,81 | | $s_r$ = 0,121 5(*P/L*) − 0,015 4 | | $s_r$ = 0,89 | | $s_r$ = 0,8 | |
| *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* — | **Repeatability limit** ($r$ = 2,77 $s_r$) | *P/L* — | **Repeatability limit** ($r$ = 2,77 $s_r$) | $I_e$ % | **Repeatability limit** ($r$ = 2,77 $s_r$) | ER % | **Repeatability limit** ($r$ = 2,77 $s_r$) |
| 350 | 44 | 82 | 8 | 170 | 30 | 26,6 | 2,2 | 1,50 | 0,46 | 62,5 | 2,5 | 68,4 | 2,3 |
| 360 | 45 | 84 | 8 | 175 | 30 | 27,1 | 2,2 | 1,55 | 0,48 | | | 68,7 | 2,3 |
| 370 | 46 | 86 | 8 | 180 | 31 | 27,6 | 2,2 | 1,60 | 0,50 | | | 69,0 | 2,3 |
| 380 | 47 | 88 | 8 | 185 | 32 | 28,1 | 2,2 | 1,65 | 0,51 | | | 69,2 | 2,3 |
| 390 | 48 | 90 | 8 | 190 | 32 | 28,6 | 2,2 | 1,70 | 0,53 | | | 69,4 | 2,3 |
| 400 | 49 | 92 | 8 | 195 | 33 | 29,1 | 2,2 | 1,75 | 0,55 | | | 69,7 | 2,3 |
| 410 | 50 | 94 | 8 | | | 29,6 | 2,2 | | | | | 70,0 | 2,3 |
| | | 96 | 9 | | | 30,1 | 2,2 | | | | | 70,2 | 2,3 |
| | | 98 | 9 | | | 30,6 | 2,2 | | | | | 70,4 | 2,3 |
| | | 100 | 9 | | | 31,1 | 2,2 | | | | | 70,7 | 2,3 |
| | | 102 | 9 | | | | | | | | | 71,0 | 2,3 |
| | | 104 | 9 | | | | | | | | | 71,2 | 2,3 |
| | | 106 | 9 | | | | | | | | | 71,4 | 2,3 |
| | | 108 | 9 | | | | | | | | | 71,7 | 2,3 |

**Table F.9 — Practical application of reproducibility formulae for laboratory milled flour**

| *W* | | *P* | | *L* | | *G* | | *P*/*L* | | $I_e$ | | **Extraction rate,** ER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Validity range: 82 to 406** | | **Validity range: 28 to 108** | | **Validity range: 35 to 195** | | **Validity range: 13,1 to 31,1** | | **Validity range: 0,18 to 1,77** | | **Validity range: 35,3 to 62,6** | | **Validity range: 61,7 to 71,7** | |
| $s_R = 0{,}053\,4\,W + 4{,}195\,1$ | | $s_R = 0{,}063\,7\,P + 1{,}579\,9$ | | $s_R = 0{,}099\,8\,L + 1{,}331\,1$ | | $s_R = 1{,}25$ | | $s_R = 0{,}210\,7(P/L) - 0{,}015\,4$ | | $s_R = 2{,}12$ | | $s_R = 3{,}8$ | |
| *W* $10^{-4}$ J | **Reproducibility limit** ($R = 2{,}77\,s_R$) | *P* mm | **Reproducibility limit** ($R = 2{,}77\,s_R$) | *L* mm | **Reproducibility limit** ($R = 2{,}77\,s_R$) | *G* — | **Reproducibility limit** ($R = 2{,}77\,s_R$) | *P*/*L* — | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $I_e$ % | **Reproducibility limit** ($R = 2{,}77\,s_R$) | ER % | **Reproducibility limit** ($R = 2{,}77\,s_R$) |
| 80 | 23 | 28 | 9 | 35 | 13 | 13,1 | 3,5 | 0,18 | 0,06 | 35,5 | 5,9 | 61,7 | 10,5 |
| 90 | 25 | 30 | 10 | 40 | 15 | 13,6 | 3,5 | 0,2 | 0,07 | 36,5 | 5,9 | 62,0 | 10,5 |
| 100 | 26 | 32 | 10 | 45 | 16 | 14,1 | 3,5 | 0,25 | 0,10 | 37,5 | 5,9 | 62,2 | 10,5 |
| 110 | 28 | 34 | 10 | 50 | 18 | 14,6 | 3,5 | 0,3 | 0,13 | 38,5 | 5,9 | 62,4 | 10,5 |
| 120 | 29 | 36 | 11 | 55 | 19 | 15,1 | 3,5 | 0,35 | 0,16 | 39,5 | 5,9 | 62,7 | 10,5 |
| 130 | 31 | 38 | 11 | 60 | 20 | 15,6 | 3,5 | 0,4 | 0,19 | 40,5 | 5,9 | 63,0 | 10,5 |
| 140 | 32 | 40 | 11 | 65 | 22 | 16,1 | 3,5 | 0,45 | 0,22 | 41,5 | 5,9 | 63,2 | 10,5 |
| 150 | 34 | 42 | 12 | 70 | 23 | 16,6 | 3,5 | 0,5 | 0,25 | 42,5 | 5,9 | 63,4 | 10,5 |
| 160 | 35 | 44 | 12 | 75 | 24 | 17,1 | 3,5 | 0,55 | 0,28 | 43,5 | 5,9 | 63,7 | 10,5 |
| 170 | 37 | 46 | 12 | 80 | 26 | 17,6 | 3,5 | 0,6 | 0,31 | 44,5 | 5,9 | 64,0 | 10,5 |
| 180 | 38 | 48 | 13 | 85 | 27 | 18,1 | 3,5 | 0,65 | 0,34 | 45,5 | 5,9 | 64,2 | 10,5 |
| 190 | 40 | 50 | 13 | 90 | 29 | 18,6 | 3,5 | 0,7 | 0,37 | 46,5 | 5,9 | 64,4 | 10,5 |
| 200 | 41 | 52 | 14 | 95 | 30 | 19,1 | 3,5 | 0,75 | 0,40 | 47,5 | 5,9 | 64,7 | 10,5 |
| 210 | 43 | 54 | 14 | 100 | 31 | 19,6 | 3,5 | 0,8 | 0,42 | 48,5 | 5,9 | 65,0 | 10,5 |
| 220 | 44 | 56 | 14 | 105 | 33 | 20,1 | 3,5 | 0,85 | 0,45 | 49,5 | 5,9 | 65,2 | 10,5 |
| 230 | 46 | 58 | 15 | 110 | 34 | 20,6 | 3,5 | 0,9 | 0,48 | 50,5 | 5,9 | 65,4 | 10,5 |
| 240 | 47 | 60 | 15 | 115 | 35 | 21,1 | 3,5 | 0,95 | 0,51 | 51,5 | 5,9 | 65,7 | 10,5 |
| 250 | 49 | 62 | 15 | 120 | 37 | 21,6 | 3,5 | 1 | 0,54 | 52,5 | 5,9 | 66,0 | 10,5 |
| 260 | 50 | 64 | 16 | 125 | 38 | 22,1 | 3,5 | 1,05 | 0,57 | 53,5 | 5,9 | 66,2 | 10,5 |
| 270 | 52 | 66 | 16 | 130 | 40 | 22,6 | 3,5 | 1,1 | 0,60 | 54,5 | 5,9 | 66,4 | 10,5 |
| 280 | 53 | 68 | 16 | 135 | 41 | 23,1 | 3,5 | 1,15 | 0,63 | 55,5 | 5,9 | 66,7 | 10,5 |
| 290 | 55 | 70 | 17 | 140 | 42 | 23,6 | 3,5 | 1,2 | 0,66 | 56,5 | 5,9 | 67,0 | 10,5 |
| 300 | 56 | 72 | 17 | 145 | 44 | 24,1 | 3,5 | 1,25 | 0,69 | 57,5 | 5,9 | 67,2 | 10,5 |

**Table F.9** *(continued)*

| $W$ | | $P$ | | $L$ | | $G$ | | $P/L$ | | $I_e$ | | **Extraction rate,** ER | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Validity range: 82 to 406** | | **Validity range: 28 to 108** | | **Validity range: 35 to 195** | | **Validity range: 13,1 to 31,1** | | **Validity range: 0,18 to 1,77** | | **Validity range: 35,3 to 62,6** | | **Validity range: 61,7 to 71,7** | |
| $s_R = 0{,}053\,4\,W + 4{,}195\,1$ | | $s_R = 0{,}063\,7\,P + 1{,}579\,9$ | | $s_R = 0{,}099\,8\,L + 1{,}331\,1$ | | $s_R = 1{,}25$ | | $s_R = 0{,}210\,7(P/L) - 0{,}015\,4$ | | $s_R = 2{,}12$ | | $s_R = 3{,}8$ | |
| $W$ $10^{-4}$ J | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $P$ mm | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $L$ mm | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $G$ — | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $P/L$ — | **Reproducibility limit** ($R = 2{,}77\,s_R$) | $I_e$ % | **Reproducibility limit** ($R = 2{,}77\,s_R$) | ER % | **Reproducibility limit** ($R = 2{,}77\,s_R$) |
| 310 | 57 | 74 | 17 | 150 | 45 | 24,6 | 3,5 | 1,3 | 0,72 | 58,5 | 5,9 | 67,4 | 10,5 |
| 320 | 59 | 76 | 18 | 155 | 47 | 25,1 | 3,5 | 1,35 | 0,75 | 59,5 | 5,9 | 67,7 | 10,5 |
| 330 | 60 | 78 | 18 | 160 | 48 | 25,6 | 3,5 | 1,4 | 0,77 | 60,5 | 5,9 | 68,0 | 10,5 |
| 340 | 62 | 80 | 18 | 165 | 49 | 26,1 | 3,5 | 1,45 | 0,80 | 61,5 | 5,9 | 68,2 | 10,5 |
| 350 | 63 | 82 | 19 | 170 | 51 | 26,6 | 3,5 | 1,5 | 0,83 | 62,5 | 5,9 | 68,4 | 10,5 |
| 360 | 65 | 84 | 19 | 175 | 52 | 27,1 | 3,5 | 1,55 | 0,86 | | | 68,7 | 10,5 |
| 370 | 66 | 86 | 20 | 180 | 53 | 27,6 | 3,5 | 1,6 | 0,89 | | | 69,0 | 10,5 |
| 380 | 68 | 88 | 20 | 185 | 55 | 28,1 | 3,5 | 1,65 | 0,92 | | | 69,2 | 10,5 |
| 390 | 69 | 90 | 20 | 190 | 56 | 28,6 | 3,5 | 1,7 | 0,95 | | | 69,4 | 10,5 |
| 400 | 71 | 92 | 21 | | | 29,1 | 3,5 | 1,75 | 0,98 | | | 69,7 | 10,5 |
| 410 | 72 | 94 | 21 | | | 29,6 | 3,5 | | | | | 70,0 | 10,5 |
| | | 96 | 21 | | | 30,1 | 3,5 | | | | | 70,2 | 10,5 |
| | | 98 | 22 | | | 30,6 | 3,5 | | | | | 70,4 | 10,5 |
| | | 100 | 22 | | | 31,1 | 3,5 | | | | | 70,7 | 10,5 |
| | | 102 | 22 | | | | | | | | | 71,0 | 10,5 |
| | | 104 | 23 | | | | | | | | | 71,2 | 10,5 |
| | | 106 | 23 | | | | | | | | | 71,4 | 10,5 |
| | | 108 | 24 | | | | | | | | | 71,7 | 10,5 |

# Annex G
(informative)

# Routine maintenance instructions for the Alveograph

NOTE See References [9] and [10] for more information.

## G.1 Before every test

**G.1.1** Clean the kneading chamber, the extrusion aperture and the accessories (resting plates, sheeting table, kneader blade, etc.).

**G.1.2** Check the following:

a) the laboratory temperature;

b) the kneading machine temperature;

c) the Alveograph temperature.

## G.2 Every day

**G.2.1** Each morning, check the Alveograph air flow setting (except for the Alveolab device).

**G.2.2** Carefully clean the apparatus and its accessories, including the extrusion aperture, in order to remove all dry dough (with a cloth or a sponge, not with a metal tool).

**G.2.3** After the last test of the working day, detach the kneader blade. Pay special attention to the arm and then oil it with the oil used for the Alveograph test (AlveoNG and AlveoPC models only). Clean the kneading machine bearing using a finger and a cloth and then replace the kneader blade. Clean the upper and lower parts of the Alveograph part of the apparatus using a damp cloth.

## G.3 Every week

**G.3.1** Remove all grease from the Alveograph and its accessories (resting plate, sheeting table, roller, etc.) thoroughly with a detergent. A domestic washing-up detergent is sufficient for this purpose.

**G.3.2** Check that the distance between the kneader blade and the bottom of the bowl is less than 0,3 mm and, if necessary, lubricate the bearing used to attach it to the motor.

## G.4 Every month

**G.4.1** Clean the burette (6.8) with distilled water and lubricate the tap with petroleum jelly.

**G.4.2** Check that the burette (6.8) can deliver a volume of solution equivalent to a 15 % flour moisture content in (25 ± 5) s.

**G.4.3** Remove all grease from the rest chambers (6.7) using a detergent.

## G.5 Every year

**G.5.1** Check that dust or other foreign objects are not obstructing the ventilation holes. Use bursts of dry air to remove any obstruction.

**G.5.2** Check the accuracy of burette water or of the Alveolab injection delivery with distilled water.

# Annex H
(informative)

# Assessment of proteolytic activity in wheat (*T. aestivum* L.) or flour

## H.1 General

This technique is used in some European countries to assess proteolytic activity in flour to aid the detection of flours damaged for example by heteropterous insects (see References [11], [12] and [13]).

## H.2 Principle

The detection of proteolytic activity in breadmaking wheat flour, using an Alveograph, with normal and extended resting time permits the identification of dough breakdown that can be caused by insects (particularly of the order Heteroptera).

## H.3 Reagents

As specified in Clause 5.

## H.4 Apparatus

As specified in Clause 6.

## H.5 Sampling and sample preparation

As specified in Clauses 7, 8 and Clause 9.

## H.6 Preparation and Alveograph test

### H.6.1 General

As specified in Clause 10 with the following modifications.

### H.6.2 Procedure

Test the dough test pieces obtained during the first, third and fifth extrusions (see 10.4) 28 min after the start of kneading.

Keep the dough test pieces obtained during the second and fourth extrusions (see 10.4) on the resting plate in the thermostatically controlled compartment at 25 °C.

Test these two dough test pieces 2 h after the start of kneading.

### H.6.3 Expression of Alveograph results

The values obtained after the 2 h rest period shall be considered results of a technological test and shall be recorded as follows:

— $L_1$, expressed to the nearest whole millimetre;

— $W_1$, expressed to the nearest whole unit of $10^{-4}$ J.

An estimate of this activity can be obtained by using Formulae (H.1) and (H.2):

— Proteolytic activity, $A$, expressed as a percentage:

$$A = [(W - W_1) / W] \times 100 \tag{H.1}$$

— Modification of $L$, $\Delta L$, expressed as a percentage:

$$\Delta L = [(L - L_1) / L] \times 100 \tag{H.2}$$

NOTE The addition of additives, e.g. enzyme preparations or reducing agents, can have similar effects.

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