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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Wheat flour — Physical characteristics of doughs —

Part 2: Determination of rheological properties using an extensograph

Farines de blé tendre — Caractéristiques physiques des pâtes —

Partie 2: Détermination des caractéristiques rhéologiques au moyen de l'extensographe

Reference number
ISO 5530-2 : 1988 (E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5530-2 was prepared by Technical Committee ISO/TC 34, *Agricultural food products.*

This part of ISO 5530 is based on Standard No. 114 of the International Association for Cereal Science and Technology (ICC).

ISO 5530 consists of the following parts, under the general title *Wheat flour — Physical characteristics of doughs*:

— *Part 1: Determination of water absorption and rheological properties using a farinograph*

— *Part 2: Determination of rheological properties using an extensograph*

— *Part 3: Determination of water absorption and rheological properties using a valorigraph*

— *Part 4: Determination of rheological properties using an alveograph*

Annexes A and B of this part of ISO 5530 are for information only.

Wheat flour — Physical characteristics of doughs —

Part 2: Determination of rheological properties using an extensograph

1 Scope

This part of ISO 5530 specifies a method, using an extensograph[1)], for the determination of the stretching characteristics of a wheat flour dough.

The method is applicable to flour from wheat (*Triticum aestivum* Linnaeus).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5530. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5530 are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 712 : 1985, *Cereals and cereal products — Determination of moisture content (Routine reference method).*

ISO 2170 : 1980, *Cereals and pulses — Sampling of milled products.*

ISO 5530-1 : 1988, *Wheat flour — Physical characteristics of doughs — Part 1: Determination of water absorption and rheological properties using a farinograph.*

3 Definition

For the purposes of this part of ISO 5530, the following definition applies.

stretching characteristics (of dough): The resistance of dough to extension, expressed in arbitrary units (extensograph units, EU), and the extent to which it can be stretched until breaking, also expressed in arbitrary units (millimetres transposition of the band of paper in the recorder), under the operating conditions specified in this part of ISO 5530.

4 Principle

Preparation of a dough from flour, water, and salt in a farinograph under specified conditions. Moulding of a test piece on the balling unit and moulder of the extensograph into a standard shape. After a fixed period of time, stretching the test piece, and recording the force required. Immediately after the first stretching, two repetitions, one after the other, with the same test piece, of moulding, rest period, and stretching.

The size and shape of the curves obtained are a guide to the baking characteristics of the flour.

5 Reagents

5.1 Distilled water, or water of equivalent purity.

5.2 Sodium chloride, of recognized analytical quality.

6 Apparatus

Usual laboratory equipment and, in particular, the following.

6.1 Extensograph, *with a thermostat consisting of a constant temperature water-bath (see annex A), with the following operating characteristics:*

— Rotational frequency of balling unit: (83 ± 3) min^{-1}

1) *This part of ISO 5530 has been drawn up on the basis of the Brabender Extensograph.*

This information is given for the convenience of users of this part of ISO 5530 and does not constitute an endorsement by ISO of this product.

- Rotational frequency of moulder: (15 ± 1) min^{-1}
- Hook speed: (1,45 ± 0,05) cm/s
- Chart speed: (0,65 ± 0,01) cm/s
- Force exerted per extensograph unit:
  (12,3 ± 0,3) mN/EU [(1,25 ± 0,03) gf/EU]

NOTE — Some instruments have a different calibration for force/unit deflection. The procedure described may be used with such instruments, but it is necessary for the different calibration to be taken into account when comparing the results with instruments calibrated as above.

6.2 Farinograph, connected to a similar thermostat as the extensograph, with the operating characteristics specified in ISO 5530-1, and a burette, as specified in ISO 5530-1.

6.3 Balance, accurate to 0,1 g.

6.4 Soft plastic spatula.

6.5 Conical flask, of 250 ml capacity.

7 Sampling

Carry out sampling by the method specified in ISO 2170.

8 Procedure

8.1 Determination of the moisture content of the flour

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

8.2 Preparation of sample and apparatus

8.2.1 If necessary, bring the flour to a temperature of (25 ± 5) °C. Turn on the thermostats and circulate the water, until the required temperatures are reached, prior to using the instruments. Before and during use, check the temperatures of

- the thermostats,
- the mixing bowl of the farinograph, in the hole provided for this purpose, and of
- the extensograph cabinet.

All temperatures shall be (30 ± 0,2) °C.

8.2.2 Adjust the arm of the pen of the extensograph so as to obtain zero reading, when a cradle with both its clamps plus a 150 g weight is placed in position.

8.2.3 Pour some water into the trough of each cradle support, and place them with cradles and clamps in the cabinet at least 15 min before use.

8.2.4 Uncouple the mixer of the farinograph from the driving shaft and adjust the position of the counter-weight(s) so as to obtain zero deflection of the pointer with the motor running at the specified rotational frequency (see ISO 5530-1 : 1988, 6.1.1). Switch off the motor and then couple the mixer.

Lubricate the mixer with a drop of water between its back wall and each of the blades. Check that the deflection of the pointer is within the range (0 ± 5) FU with the mixing blades rotating at the specified rotational frequency in the empty, clean bowl. If the deflection exceeds 5 FU, clean the mixer more thoroughly or eliminate other causes of friction.

Adjust the arm of the pen so as to obtain identical readings from the pointer and the recording pen.

Adjust the damper so that, with the motor running, the time required for the pointer to go from 1 000 FU to 100 FU is (1,0 ± 0,2) s.

8.2.5 Fill the burette of the farinograph, including the tip, with water at a temperature of (30 ± 5) °C.

8.3 Test portion

Weigh, to the nearest 0,1 g, the equivalent of 300 g of flour having a moisture content of 14 % (m/m). Let this mass, in grams, be m; see table 1 in ISO 5530-1 : 1988, for m as a function of moisture content.

Place the flour into the farinograph mixer. Cover the mixer, and keep it covered until the end of mixing (8.4.2), except for the shortest possible time, when water has to be added, and the dough scraped down (see ISO 5330-1 : 1988, A.2.2).

8.4 Preparation of the dough

8.4.1 Place (6,0 ± 0,1) g of the sodium chloride (5.2) in the conical flask (6.5). Run in approximately 135 ml of water from the burette and dissolve the salt. For flours having a low water absorption, a smaller volume of water shall be used.

8.4.2 Mix in the farinograph mixer at the specified rotational frequency (see ISO 5530-1 : 1988, 6.1.1) for 1 min or slightly longer. Pour the salt solution (8.4.1) through a funnel into the centre hole of the bottom part of the lid, when a whole-minute line on the recorder paper passes by the pen.

NOTES

1 In order to reduce the waiting time, the recorder paper may be moved forward during mixing of the flour. Do not move it backwards.

2 With older farinographs, the bowl of which is covered by a single plate (see ISO 5530-1 : 1988, A.2.2), the salt solution is poured into the right-hand front corner of the bowl.

Add from the burette into the right-hand front corner of the mixer a volume of water close to that expected to obtain a consistency of 500 FU after mixing for 5 min. When the dough forms, scrape down the sides of the bowl with the spatula (6.4), adding any adhering particles to the dough, without stopping the mixer. If the consistency is too high, add a little more water to obtain a consistency of 500 FU after mixing for 5 min. Stop mixing and clean the mixer.

NOTE — If the first dough meets the requirements of 8.4.3, test pieces from it can be moulded (8.4.4) and stretched (8.5.1).

8.4.3 Make further mixings as necessary, until a dough is obtained

— to which the salt solution and water have been added within 25 s;

— the consistency of which, measured at the centre of the curve, after mixing for 5 min, is between 480 FU and 520 FU; and

— the mixing time of which is (5 ± 0,1) min.

Stop mixing after this time.

8.4.4 Take a support with two cradles from the cabinet; remove their clamps. Remove the dough from the mixer. Weigh a (150 ± 0,5) g test piece. Place it in the balling unit and perform 20 revolutions of the plate. Remove from the balling unit and pass once through the moulder, ensuring that the test piece enters the back centrally, base first. Roll the test piece off the moulder into the centre of a cradle, and clamp it. Set the timer for 45 min. Weigh a second test piece, and ball, mould, and clamp it in the same way. Place the support with two cradles and test pieces into the cabinet.

NOTES

1 Very sticky doughs may be dusted lightly with rice flour or starch before entering the moulder.

2 In the case of doughs showing substantial elastic recovery, the clamps shall be held down for a few seconds to ensure that they fix the dough properly.

Clean the farinograph mixer.

8.5 Determination

8.5.1 Exactly 45 min after clamping the first test piece, place the first cradle in the balance arm; the bridge between the two halves of the cradle shall be on the left-hand side so as not to be touched by the stretching hook when travelling. Adjust the pen to zero force. Immediately start the stretching hook. Observe the test piece (see note in 9.3). After rupture of the piece, remove the cradle.

NOTE — In recent extensographs, the hook automatically returns to its upper position. With older models, it is necessary, by means of a switch, to stop the hook after breaking of the test piece, and to start it returning to its upper position.

8.5.2 Collect the dough from the cradle and the hook. Repeat the balling and moulding operations as described in 8.4.4 on this test piece. Reset the timer for 45 min.

8.5.3 Turn the recorder paper back to the same starting position as for the first test piece. Repeat the stretching operation (8.5.1) on the second test piece. Collect the dough from the cradle and the hook. Repeat the balling and moulding operations (8.4.4) on the second test piece.

8.5.4 Repeat the stretching, balling, and moulding operations described in 8.5.1, 8.5.2 and 8.5.3, returning the moulded test pieces to the cabinet. These operations take place after slightly more than 90 min from the end of mixing.

8.5.5 Repeat the operation described in 8.5.1, stretching both test pieces in turn. This takes place after slightly more than 135 min from the end of mixing.

9 Expression of results

9.1 Water absorption

Calculate the extensograph water absorption, expressed in millilitres per 100 g of flour at 14 % (m/m) moisture content, as specified in ISO 5530-1 : 1988, 9.1, for the 300 g mixer.

9.2 Resistance to stretching

9.2.1 Maximum resistance

Take as the maximum resistance to stretching, R_m, the mean of the maximum heights of the extensograph curves (see figure 1) from the two test pieces, provided that the difference between them does not exceed 20 % of their mean value.

Report each of the mean values of $R_{m,45}$, $R_{m,90}$, and $R_{m,135}$ to the nearest 5 EU.

9.2.2 Resistance at constant deformation

Some workers prefer to measure the height of the curve at a fixed extension of the test piece, usually corresponding to 50 mm transposition of the recorder paper. The extension is measured from the moment that the hook touches the test piece, i.e. when the force is suddenly different from zero.

Take as the result of the resistance to stretching at constant deformation, R_{50}, the mean of the heights of the extensograph curves after 50 mm transposition of the recorder paper (see figure 1) from the two test pieces, provided that the difference between them does not exceed 25 % of their mean value.

Report each of the mean values of $R_{50,45}$, $R_{50,90}$, and $R_{50,135}$ to the nearest 5 EU.

NOTE — Owing to the greater depression of the cradle, a more resistant test piece will be extended less at 50 mm transposition of the recorder paper than a less resistant test piece. It is possible, by means of a suitable template, to read the resistances of all test pieces at the same net extension. If such a template is used, it is necessary to mention this in the test report.

9.3 Extensibility

The extensibility, E, is the distance travelled by the recorder paper from the moment that the hook touches the test piece until rupture of (one of the strings of) the test piece; rupture is indicated on the extensograph curve either by a smooth fall of the curve almost to zero force, or by a sharp break in the curve (see figure 1).

NOTE — Beyond the breaking point, the course of the recording depends on the inertia of the lever system and on the time interval between the breaking of the two strings of the test piece. For the measurement of the extensibility, the curve is supposed to proceed, from the breaking point, along a circular ordinate line (dashed line in figure 1) down to zero force. For properly identifying the breaking point on the curve it is necessary to observe the test piece when breaking.

Take as result of the extensibility the mean distance on the extensograph curves from the two test pieces, provided that the difference between them does not exceed 15 % of their mean value.

Report each of the mean values of E_{45}, E_{90} and E_{135} to the nearest millimetre.

9.4 Repetition

If one or more of the differences between measurements on the two test pieces exceed the values specified in 9.2 and 9.3, repeat the operations in 8.4 and 8.5.

9.5 Precision

Data on the precision of the method have not been analysed in accordance with ISO 5725[1]. However, annex B gives information on results of some inter-laboratory tests.

10 Test report

The test report shall specify the method used and the results obtained. It shall also mention all operating details not specified in this part of ISO 5530 — in particular a ratio between force and deflection different from 12,3 mN/EU (1,25 gf/EU), and a possible correction for cradle depression (see 9.2.2) — or regarded as optional, together with details of any incidents which may have influenced the results, for example a deviating rotational frequency of the balling unit.

The test report shall include all information necessary for the complete identification of the sample.

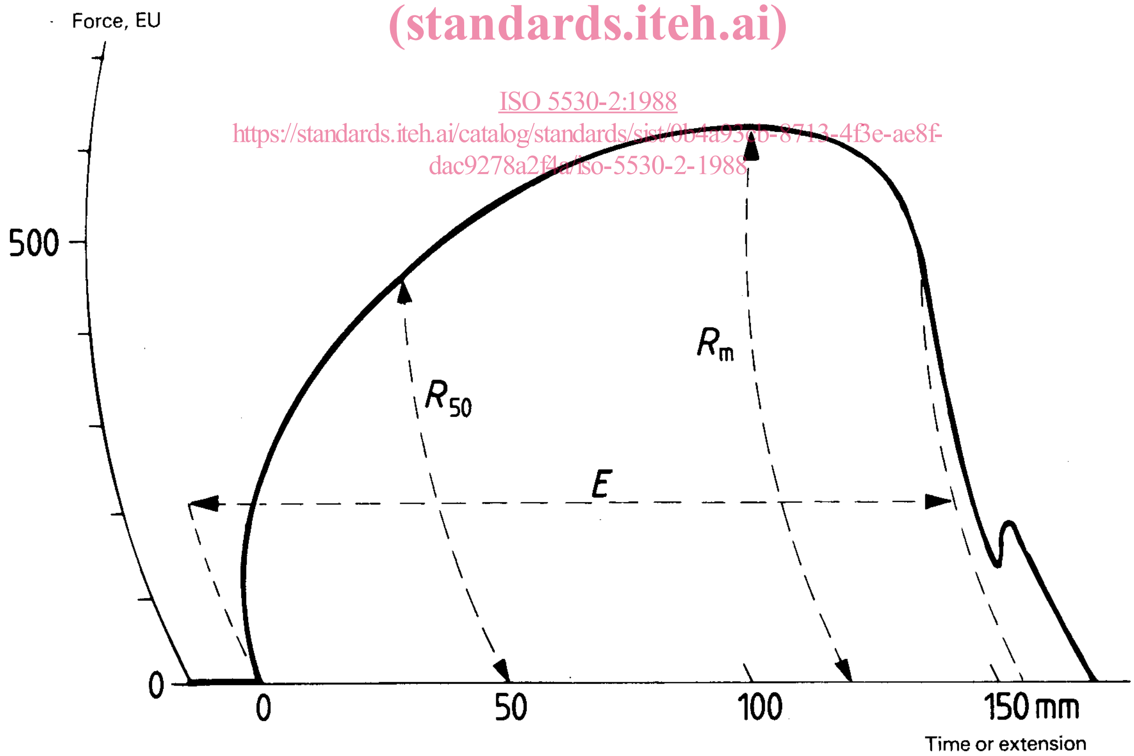


Figure 1 — Representative extensogram showing the commonly measured indices

1) ISO 5725 : 1986, *Precision of test methods — Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

Annex A
(informative)

Description of the extensograph

A.1 General description

The extensograph comprises two units:

a) the extensograph unit itself (A.2);

b) a thermostat for circulating water (A.3).

The extensograph is used in conjunction with the farinograph, which also comprises a thermostat (see ISO 5530-1).

A.2 Extensograph unit

A.2.1 General

The extensograph unit is mounted on a heavy cast-iron base plate having four levelling screws, and consists of:

a) a balling unit or rounder (A.2.2);

b) a moulder or shaper (A.2.3);

c) cradles and clamps for holding the test pieces, and cradle supports;

d) a three-section rest cabinet (A.2.4);

e) a device for stretching a test piece (A.2.5);

f) means for recording the resistance to stretching and the extensibility of the test piece in the form of extensograms (A.2.6).

The stretching device and means for recording are illustrated diagrammatically in figure A.1.

A.2.2 Balling unit

The balling unit consists of a bottomless box with a loaded lid. Beneath the box a flat plate rotates; in its centre, it carries a pin on which the dough is impaled. The rotational frequency of the balling unit shall be (83 ± 3) min^{-1}.

Water from the thermostat circulates through the hollow side-walls of the box to control its temperature.

NOTE — Some instruments made before 1965 can have a rotational frequency of 112 min^{-1}. If such an instrument is used, it is necessary to mention this in the test report.

A.2.3 Moulder

The moulder consists of a horizontal roller revolving inside an incomplete cylinder at a rotational frequency of (15 ± 1) min^{-1}. The cylinder has a metal plate attached to its inner wall. The dough is thus subjected to a moulding action between the roller and the metal plate.

Water from the thermostat circulates through the hollow incomplete cylinder to control its temperature.

A.2.4 Rest cabinet

The temperature-controlled rest cabinet consists of three sections, each one for one cradle support with two cradles, and each one with a door.

The test pieces, having been balled and moulded, are rested in the cradles on their supports in the rest cabinet. Each of the cradle supports carries two cradles and has a trough containing water to prevent skinning of the test pieces.

A.2.5 Stretching device

The cylindrical test piece, in a cradle, is supported in a horizontal position by two arms attached to one end of a pivotally mounted lever which carries a counter-weight at the other end. A hook in contact with the centre of the upper side of the test piece is caused to move vertically downwards by the action of an electrical motor, at a speed of (1,45 ± 0,05) cm/s, thereby stretching the test piece. Downward movement of the dough hook is continued until the test piece breaks.

The mechanism actuating the stretching hook has automatic limit switches which terminate the movement when the hook reaches either the top or the bottom limit. In recent extensographs, the hook, having reached the bottom position, automatically returns to its top position.

The resistance of the dough to stretching results in a downward movement of the lever carrying the cradle with the test piece.

A.2.6 Recorder

Movement of the lever carrying the cradle with the test piece is transmitted by a further system of levers to a pen which is thereby caused to move over a band of paper, recording the movement in the form of an extensogram. Movements of the lever system and recorder pen are damped by a piston immersed in oil; the piston is connected to the lever carrying the cradle.

The paper for the recorder is supplied in the form of a roll. It is moved by an electric clock-type motor at a rate of (0,65 ± 0,01) cm/s. Along its length it bears a printed scale in centimetres. Across its width it bears a circular scale (radius 200 mm) with arbitrary units, running from 0 to 1 000 extensograph units.

A.3 Thermostat

The thermostat normally consists of a tank with water, and contains the following parts.

a) An electric heating element.

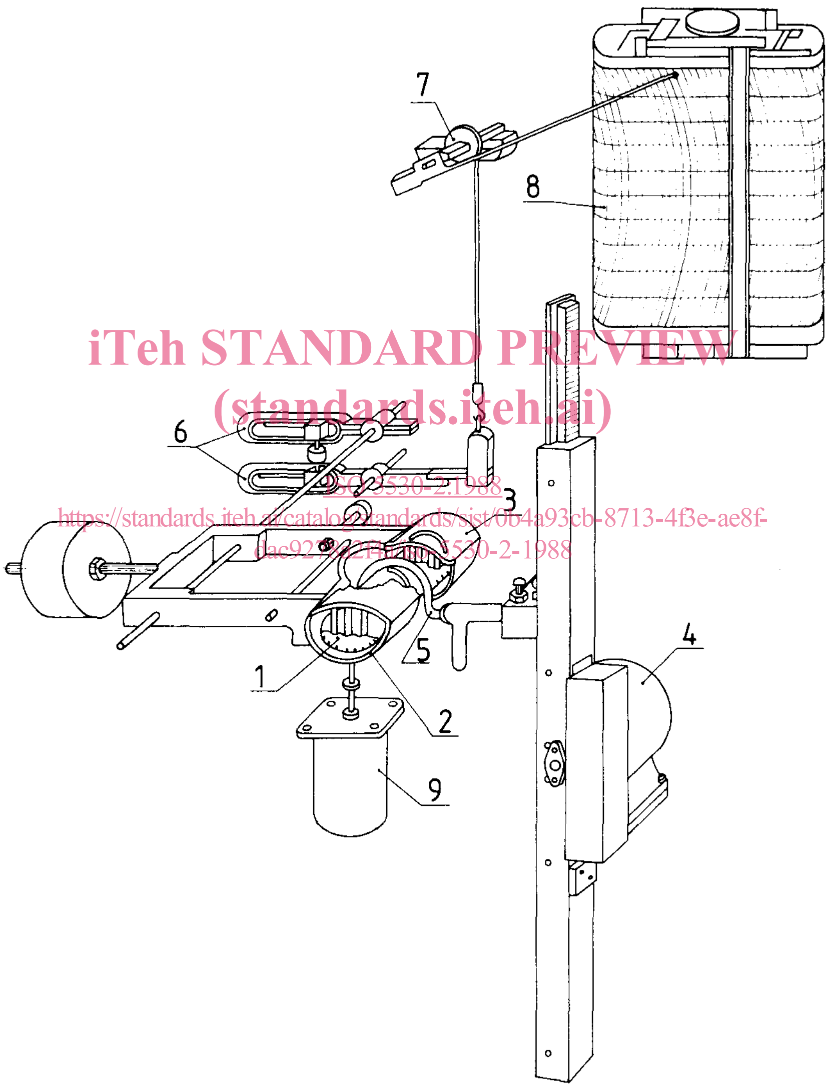
b) A thermoregulator that controls the heating element; they shall be capable of maintaining the temperature of the balling unit, moulder, and rest cabinet of the extensograph at (30 ± 0,2) °C. Under adverse conditions, a slightly higher temperature of the water may be necessary; it shall be controlled with the same accuracy.

c) A thermometer.

d) A motor-driven pump and stirrer. The pump is connected to the extensograph by means of flexible tubing. It shall have sufficient capacity to maintain the temperature of the rest cabinet at (30 ± 0,2) °C.

e) A coil of metal tubing to cool the thermostat bath by a flow of tap water.

It is recommended not to use one thermostat for both the farinograph and extensograph. If this is done, however, the two instruments shall be served by separate pumps.



1 Test piece
2 Cradle
3 Clamp for cradle
4 Electric motor
5 Stretching hook
6 Lever system
7 Scale
8 Recorder
9 Dash-pot damper

Figure 2 — Diagram of the stretching device and recorder of the extensograph

Annex B
(informative)

Precision

B.1 Repeatability

The data given in table B.1 are based on inter-laboratory tests performed between 1966 and 1972 by the International Association for Cereal Science and Technology (ICC).

Table B.1 — Repeatability standard deviation and coefficient of variation

	Standard deviation
Water absorption	0,25 % *)
	Coefficient of variation
Maximum resistance, R_m	6 %
Resistance at constant deformation, R_{50}	8 %
Extensibility, E	5 %

*) ml per 100 g of flour.

B.2 Reproducibility

The lever system and scale of an extensograph can be adjusted to give correct results.

There is no method for absolute adjustment of farinograph-extensograph combinations. Each combination shall be compared with another combination using a range of flours. It is possible to have the extensograph adjusted by the manufacturer to his standard. With old or badly worn instruments, however, this may be impossible. If good agreement between instruments is to be maintained, frequent checks are required.

Differences between various laboratories are roughly characterized by the following data. They refer to mean values of two stretchings from one mixing.

Table B.2 — Reproducibility coefficient of variation

	Coefficient of variation
Resistance, either maximum, R_m, or at constant deformation, R_{50}	20 %
Extensibility, E	10 %