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Flexible cellular polymeric materials — Determination of tensile strength and elongation at break

Matériaux polymères alvéolaires souples — Détermination de la résistance à la traction et de l'allongement à la rupture

Reference number
ISO 1798:2008(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 1798 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses)*.

This fourth edition cancels and replaces the third edition (ISO 1798:1997), which has been technically revised. It also incorporates the Technical Corrigendum ISO 1798:1997/Cor.1:2003. The main change is the introduction of a second type of test piece (see Figure 1) and a comparison of the results obtained with the two test pieces (see Annex A).

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Flexible cellular polymeric materials — Determination of tensile strength and elongation at break

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard specifies a method for determining the strength and deformation properties of flexible cellular materials when a test piece is extended at a constant rate until it breaks.

2 Normative references

The following referenced documents are indispensable for the application 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 1923, *Cellular plastics and rubbers — Determination of linear dimensions*

ISO 7500-1:2004, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
tensile strength
TS
maximum tensile stress applied when stretching a test piece to rupture

3.2
elongation at break
E_b
percentage elongation of a test piece at rupture

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4 Apparatus

4.1 Tensile-testing machine, complying with the following requirements:

— the rate of travel of the power-actuated grip shall be 500 mm/min ± 50 mm/min and shall be uniform at all times;

— the accuracy of the machine shall conform to class 0,5 or class 1 of ISO 7500-1:2004 for force-measurement over the range of loading employed.

For the determination of elongation at break, the machine may be equipped with either a mechanical or an optical extensometer. If used, however, the extensometer shall comply with the following requirements which shall be verified in accordance with ISO 9513:

— initial gauge length accurate to ± 1 %;

— gauge length at break accurate to ± 1,25 mm.

When a mechanical contact extensometer is used, care shall be taken that the contact elements do not damage the test piece. In addition, their mass and inertia shall not influence the determination of the maximum tensile strength by more than 1 %.

5 Test pieces

5.1 Direction of sampling

If the product shows a predominant direction of the cellular structure (orientation of the cells), the test pieces for the tensile test shall be taken in such a way that their longitudinal axes lie at right angles to this predominant direction. If it is not possible, the location of the longitudinal axis with respect to the predominant direction shall be stated in the test report.

5.2 Shape and dimensions

The test pieces shall be rectangular in cross-section, with or without skin, and without visible defects. The test pieces shall be cut out with one of the two types of test piece cutter shown in Figure 1 and shall be 10 mm to 15 mm thick.

5.3 Number of test pieces

Unless agreed otherwise between the interested parties, sufficient test pieces shall be tested to provide five breaks within the gauge length.

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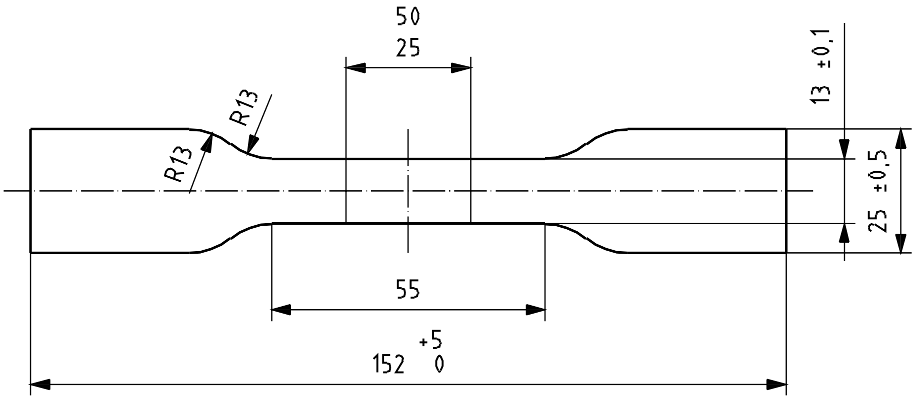
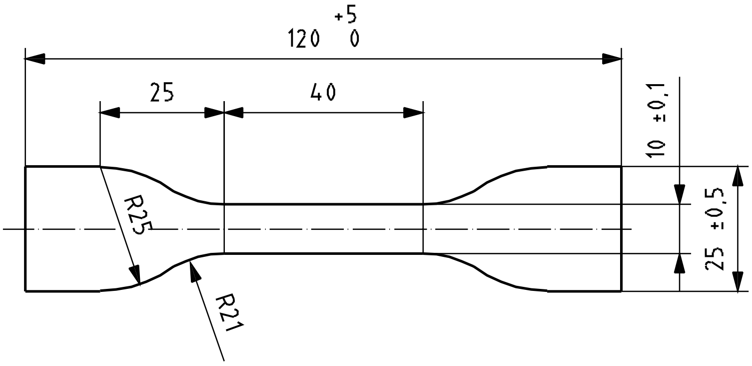
Dimensions in millimetres



a) **Type 1**



b) **Type 1A**

Figure 1 — Test-piece cutters

5.4 Conditioning

5.4.1 The test pieces or the material from which the test pieces are to be cut shall be prepared and conditioned in accordance with ISO 23529, unless otherwise specified.

5.4.2 Materials shall not be tested less than 72 h after manufacture, unless at either 16 h or 48 h after manufacture it can be demonstrated that the mean results do not differ by more than ± 10 % from those obtained after 72 h. Testing is permitted at either 16 h or 48 h if, at the specified time, the above criterion has been satisfied.

Prior to the test, the test pieces or the material from which the test pieces are to be cut shall be conditioned for at least 16 h in one of the following atmospheres:

— 23 °C ± 2 °C, (50 ± 5) % relative humidity;

— 27 °C ± 2 °C, (65 ± 5) % relative humidity.

This period can form the latter part of the period following manufacture.

5.4.3 In the case of quality-control tests, test pieces can be taken a shorter time (down to a minimum of 12 h) after manufacture and testing carried out after conditioning for a shorter period (down to a minimum of 6 h) in one of the atmospheres specified above.

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6 Procedure

6.1 After conditioning as specified in 5.4, measure the thickness of the material at five evenly distributed points in the area from which the test pieces are to be cut. These measurements shall be made in accordance with ISO 1923 and shall not vary from each other by more than ± 2 %. If desired, thickness measurements can be performed on cut test pieces, but test pieces whose thickness falls outside these limits shall be rejected.

6.2 Mark the gauge length on each test piece with two reference lines, using a marker with two parallel marking edges. Measure the distance between the inside edges of the lines to an accuracy of ± 1 % (these lines shall be at least 25 mm and not more than 50 mm apart for type 1 test pieces and not more than 40 mm apart for type 1A test pieces).

6.3 Set the load-indicating device to zero and place a test piece in the grips of the tensile-testing machine (4.1), taking care to mount the test piece symmetrically so that the tension will be distributed uniformly over its cross-section. A preload stress of up to 0,1 kPa or a preload extension of up to 0,5 % may be applied. When using an extensometer, zero it on completion of the preload. Start the machine at a jaw-separation rate of 500 mm/min ± 50 mm/min and record the maximum force (measured to ± 1 %) and the distance between the inside edges of the two reference lines (measured to ± 1,25 mm) immediately prior to break of the test piece. Reject test pieces which break outside the gauge length, and continue testing until five satisfactory results are obtained. Sufficient material will have to be available to ensure that retesting can be carried out.

6.4 Carry out the test at the same temperature and humidity as that used for conditioning the test material.

NOTE In the case of the type 1 cutter, the probability of test pieces being rejected can be minimized by selecting a gauge length close to the maximum permitted value of 50 mm.

7 Calculation

7.1 Tensile strength

Calculate the average thickness of each test piece.

Calculate the average initial cross-sectional area of each test piece on the basis of the average thickness and the width of the central section of the test piece cutter (13 mm for type 1 and 10 mm for type 1A).

The tensile strength (TS) of each test piece, expressed in kilopascals, is given by the equation

$$\mathrm{TS} = \frac{F}{A} \times 10^3$$

where

F is the maximum force, in newtons;

A is the average initial cross-sectional area, in square millimetres.

7.2 Elongation at break

The elongation at break, E_b, expressed as a percentage of the original gauge length, is given by the equation

$$E_\mathrm{b} = \frac{L - L_0}{L_0} \times 100$$

where

L is the gauge length at break, in millimetres;

L_0 is the initial gauge length, in millimetres.

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8 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) the nature of the cellular material;

c) the type of test piece used;

d) details of test piece conditioning;

e) the location in the product from which the test pieces were taken, and the predominant direction of the cellular structure, if any;

f) the location and number of surfaces with skin, if any;

g) the test piece thickness;

h) the median value of the tensile strength, in kilopascals;

i) the median value of the elongation at break, in percent;

j) any deviations from this International Standard.

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Annex A
(informative)

Comparative testing of type 1 and type 1A test pieces

A.1 General

This annex gives a comparison of test results obtained with the new type 1A test piece and the old type 1 test piece.

A.2 Comparative testing

Two types of test piece (type 1 and type 1A) were used.

Two types of flexible polyurethane foam were used:

— sample A: 22 kg/m^3 general-purpose type;

— sample B: 32 kg/m^3 high-hardness type.

Both samples were of the polyether type.

In order to ensure the accuracy of the test, the test pieces were cut from the same test material with the same test piece cutter. Fifteen test pieces were prepared for each test.

Testing was carried out at seven laboratories in Japan on two days in different weeks.

The test method and test piece conditioning were as specified in ISO 1798:1997.

A.3 The test method and the rate of breaking outside the gauge length

The type 1 test pieces were marked with gauge lengths of 25 mm, 40 mm, 50 mm and 55 mm. Although ISO 1798 specifies a gauge length of 25 mm to 50 mm, a gauge length of 55 mm was included since there was room for it within the narrow portion of the test piece.

The type 1A test piece was marked only at 40 mm since the gauge length of the test piece is specified as 40 mm.

The frequency of breaking outside the gauge length was calculated as a percentage from the following equation:

$$k = \frac{O}{T} \times 100$$

where

k is the frequency of breaking outside the gauge length, in percent;

O is the number of test pieces that broke outside the gauge length during the two days;

T is the total number of test pieces tested during the two days.

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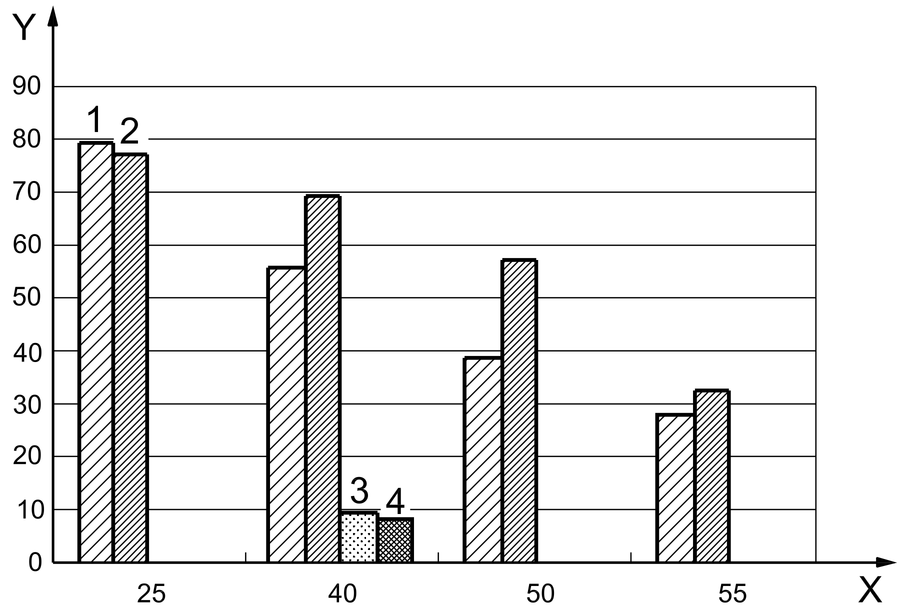
The test results are shown in Table A.1 and Figure A.1.

Table A.1 — Number of test pieces that broke outside the gauge length and the total number of test pieces

	Sample A					Sample B				
	Type 1				Type 1A	Type 1				Type 1A
Gauge length	25 mm	40 mm	50 mm	55 mm	40 mm	25 mm	40 mm	50 mm	55 mm	40 mm
	Number of test pieces that broke outside the gauge length									
Day1/day2	71/76	49/39	31/14	13/15	1/6	78/82	63/61	43/47	12/23	4/2
Total	147	88	45	28	7	160	124	90	35	6
	Total number of test pieces tested									
Day1/day2	94/91	87/74	66/49	48/50	36/41	102/103	93/88	76/82	57/47	39/37
Total	185	161	115	98	77	205	181	158	104	76



Key

X gauge length, mm

Y frequency of breaking outside the gauge length, %

1 sample A (type 1 test piece)

2 sample B (type 1 test piece)

3 sample A (type 1A test piece)

4 sample B (type 1A test piece)

Figure A.1 — Frequency of breaking outside the gauge length

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A.4 Analysis of test piece breaking point position

In three of the laboratories, chosen at random from the seven laboratories participating in the test programme, the positions of the breaking points on the test pieces were measured as shown in Figure A.2 and the distance of the breaking point from the centre of the test piece was calculated from the following equation:

$$D = \left| D_1 - D_2 \right|$$

where

D is the distance of the breaking point from the centre of the test piece, in millimetres;

D_1 is the distance from the breaking point to one end of the test piece, in millimetres;

D_2 is the distance from the breaking point to the other end of the test piece, in millimetres.

Since the position of the breaking point does not have any correlation with the gauge length, test pieces breaking both inside and outside the gauge length were measured.

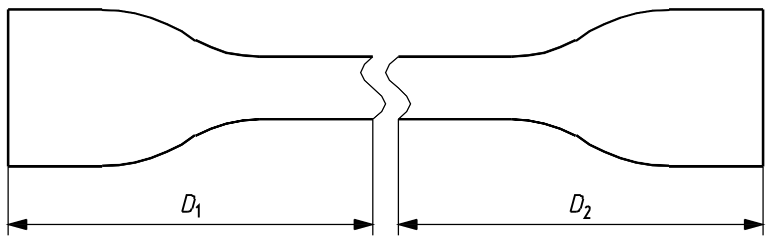

Figure A.2 — Measurement of position of breaking point

The test results are summarized in the form of histograms in Figure A.3.

The horizontal axis represents the value of D calculated in the equation above. A large value of D means that the breaking point is far away from the centre of the test piece.

The vertical axis represents the number of test pieces.

The weighted average is indicated by a vertical line in each histogram.

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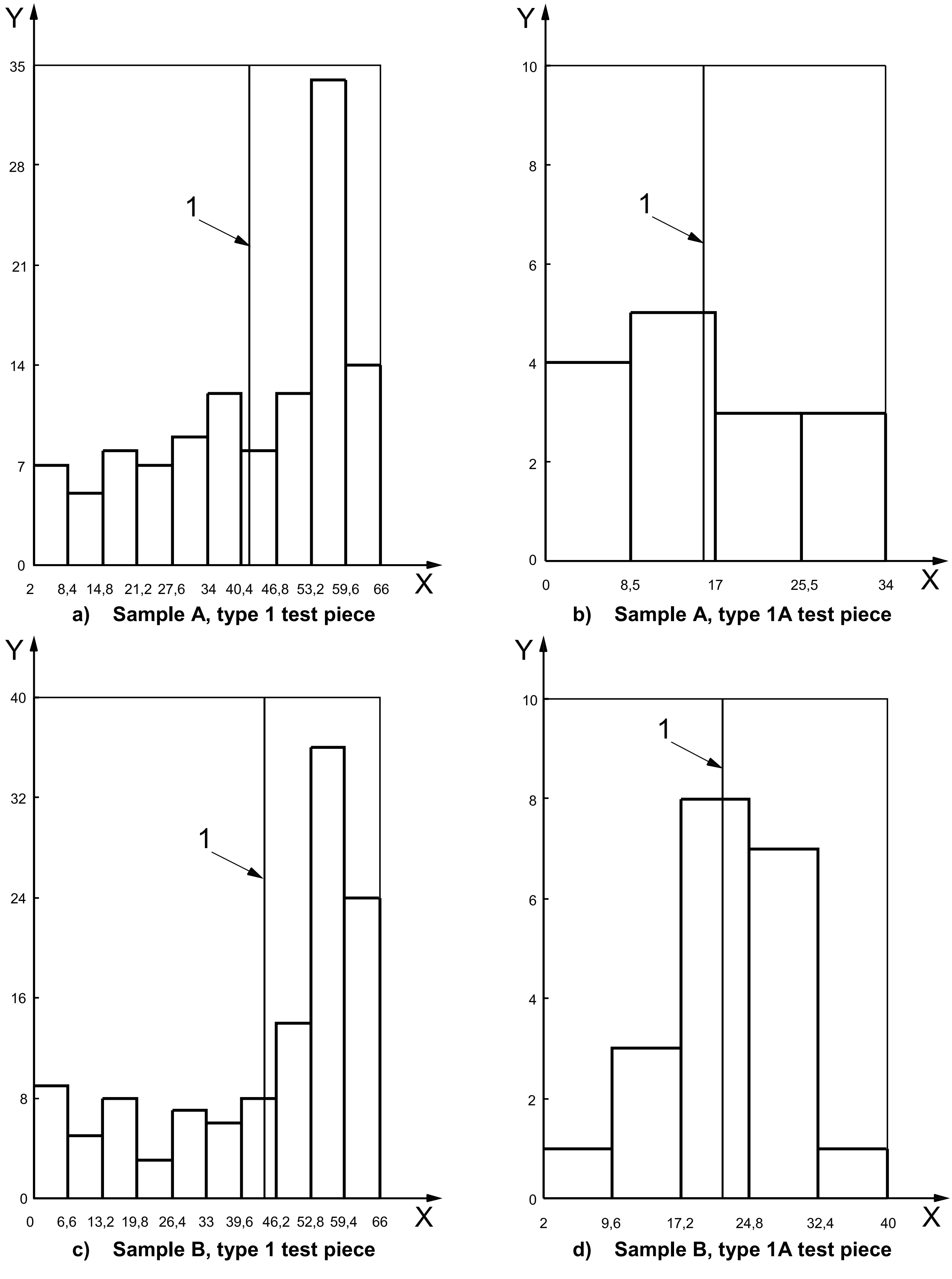

Key

X distance of breaking point from centre of test piece (mm)

Y number of test pieces

1 weighted average

Figure A.3 — Comparison of breaking point position for type 1 and type 1A test pieces

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A.5 Verification of the precision of the test results

The precision of the tensile strength and the elongation results obtained for each type of test piece was calculated in accordance with ISO/TR 9272. For the type 1 test piece, the precision data are based on the results obtained with a gauge length of 50 mm.

The precision data in this annex should not be used for acceptance or rejection of any group of materials without documentation that the results of this precision evaluation are actually applicable to the particular material tested.

Repeatability — The repeatability, or local domain precision, of this test method has been established as the values given in Table A.2 and Table A.3 for each precision parameter listed in the tables. The test results (obtained by the proper use of this International Standard) that differ by more than the tabulated values of r, in measurement units, or (r), in percent, should be considered as suspect, i.e. to have come from different populations. Such a decision suggests that some appropriate investigation action be taken.

Reproducibility — The reproducibility, or global domain precision, of this test method has been established as the values given in Table A.2 and Table A.3 for each measurement parameter listed in the tables. The test results obtained in different laboratories (by the proper use of this International Standard) that differ by more than the tabulated values of R, in measurement units, or (R), in percent, should be considered as suspect, i.e. to have come from different populations. Such a decision suggests that some appropriate investigative action be taken.

Table A.2 — Precision data for tensile strength of each type of test piece

Sample (density)	Test piece	Tensile strength						
		Mean value	Within laboratory			Between laboratories		
		kPa	s_r	r	(r)	s_R	R	(R)
A (22 kg/m^3)	Type 1	132,2	1,944	5,50	4,16	6,307	17,85	13,50
	Type 1A	135,7	1,587	4,49	3,31	6,526	18,47	13,61
B (32 kg/m^3)	Type 1	154,3	2,244	6,35	4,12	2,679	7,58	4,91
	Type 1A	157,5	1,462	4,14	2,63	4,835	13,68	8,69

Table A.3 — Precision data for elongation at break of each type of test piece

Sample (density)	Test piece	Elongation						
		Mean value	Within laboratory			Between laboratories		
		%	s_r	r	(r)	s_R	R	(R)
A (22 kg/m^3)	Type 1	150,6	1,949	5,52	3,67	7,571	21,43	14,23
	Type 1A	151,4	1,183	3,35	2,21	2,151	6,09	4,02
B (32 kg/m^3)	Type 1	110,1	1,517	4,29	3,90	4,310	12,20	11,08
	Type 1A	118,1	1,449	4,10	3,47	6,917	19,58	16,58

A.6 Summary

Since the new test piece (type 1A) essentially eliminates fracture outside the gauge length, it reduces the time required for testing. In addition, the precision of the test results is high. It is therefore considered suitable for use in the tensile testing of flexible cellular materials.

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Bibliography

[1] ISO 1798:1997, *Flexible cellular polymeric materials — Determination of tensile strength and elongation at break* (now withdrawn)

[2] ISO/TR 9272, *Rubber and rubber products — Determination of precision for test method standards*

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