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Rubber, vulcanized or thermoplastic — Determination of tear strength —

Part 1: Trouser, angle and crescent test pieces

Caoutchouc vulcanisé ou thermoplastique — Détermination de la résistance au déchirement —

Partie 1: Éprouvettes pantalon, angulaire et croissant

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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.

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 documents 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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This fifth edition cancels and replaces the fourth edition (ISO 34-1:2015), which has been technically revised.

The main changes are as follows:

— the detailed information regarding the methods in Clause 1 have been moved to Clause 4;

— Figure 4 in 5.5 has been revised;

— expressions in Clauses 7 and 11 have been modified to avoid unexpected misunderstandings and to get precise results.

A list of all parts in the ISO 34 series can be found on the ISO website.

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.

Rubber, vulcanized or thermoplastic — Determination of tear strength —

Part 1:
Trouser, angle and crescent test pieces

WARNING 1 — Persons using this document should be familiar with normal laboratory practice. This document 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 determine the applicability of any other restrictions.

WARNING 2 — Certain procedures specified in this document can involve the use or generation of substances, or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

1 Scope

This document specifies three test methods for the determination of the tear strength of vulcanized or thermoplastic rubber, namely the following:

— method A, using a trouser test piece;

— method B, using an angle test piece, with or without a nick of specified depth;

— method C, using a crescent test piece with a nick.

The value of tear strength obtained depends on the shape of the test piece, speed of stretching, and temperature of test. It can also be susceptible to grain effects in rubber.

NOTE A separate method for the determination of the tear strength of small test pieces of rubber (Delft test pieces) is specified in ISO 34-2.

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 1382, *Rubber — Vocabulary*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 6133, *Rubber and plastics — Analysis of multi-peak traces obtained in determinations of tear strength and adhesion strength*

ISO 18899:2013, *Rubber — Guide to the calibration of test equipment*

ISO 23529:2016, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1382 and the following apply.

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/

3.1
trouser tear strength
median force required to propagate a cut in a specified trouser-shaped test piece by tearing, divided by the thickness of the test piece, the force acting in a direction substantially in the plane of the cut

Note 1 to entry: The median force is calculated in accordance with ISO 6133.

3.2
unnicked angle tear strength
maximum force required to rupture a specified angle-shaped test piece, divided by the thickness of the test piece, the force acting in a direction substantially along the length of the test piece

3.3
nicked angle tear strength
maximum force required to cause a nick cut in a specified angle-shaped test piece to extend by tearing of the rubber, divided by the thickness of the test piece, the force acting in a direction substantially normal to the plane of the nick

3.4
crescent tear strength
maximum force required to cause a nick cut in a specified crescent-shaped test piece to extend by tearing of the rubber, divided by the thickness of the test piece, the force acting in a direction substantially normal to the plane of the nick

4 Principle

4.1 General

The test consists in measuring the force required to tear a specified test piece, in continuation of the cut or nick already produced in the test piece or, in the case of method B, procedure (a), completely across the width of the test piece.

The tearing force is applied by means of a tensile testing machine, operated without interruption at a constant rate of traverse until the test piece breaks. Dependent upon the method employed, the maximum or median force achieved is used to calculate the tear strength.

No correlation between data obtained by the alternative test pieces is implied.

4.2 Method A: Method to determine trouser tear strength

Method A, using the trouser test piece, is preferred because it is not sensitive to the length of the cut, unlike the other two test pieces in which the nick has to be very closely controlled. In addition, the results obtained are more easily related to the fundamental tear properties of the material and are less sensitive to modulus effects (provided that the leg extension is negligible) and the rate of propagation of the tear is directly related to the rate of grip separation. With some rubbers, the propagation of tear is not smooth (knotty tear), and analysis of results can be difficult[3].

4.3 Method B, procedure (a): Method to determine unnicked angle tear strength

This test is a combination of tear initiation and propagation. Stress is built up at the point of the angle until it is sufficient to initiate a tear and then further stresses propagate this tear. However, it is only possible to measure the overall force required to rupture the test piece, and, therefore, the force cannot be resolved in two components producing initiation and propagation[4].

4.4 Method B, procedure (b): Method to determine nicked angle tear strength

This test measures the force required to propagate a nick already produced in the test piece. The rate of propagation is not directly related to the jaw speed[5].

4.5 Method C: Method to determine crescent tear strength

This test also measures the force required to propagate a nick already produced in the test piece, and the rate of propagation is not related to the jaw speed.

5 Apparatus

5.1 Dies

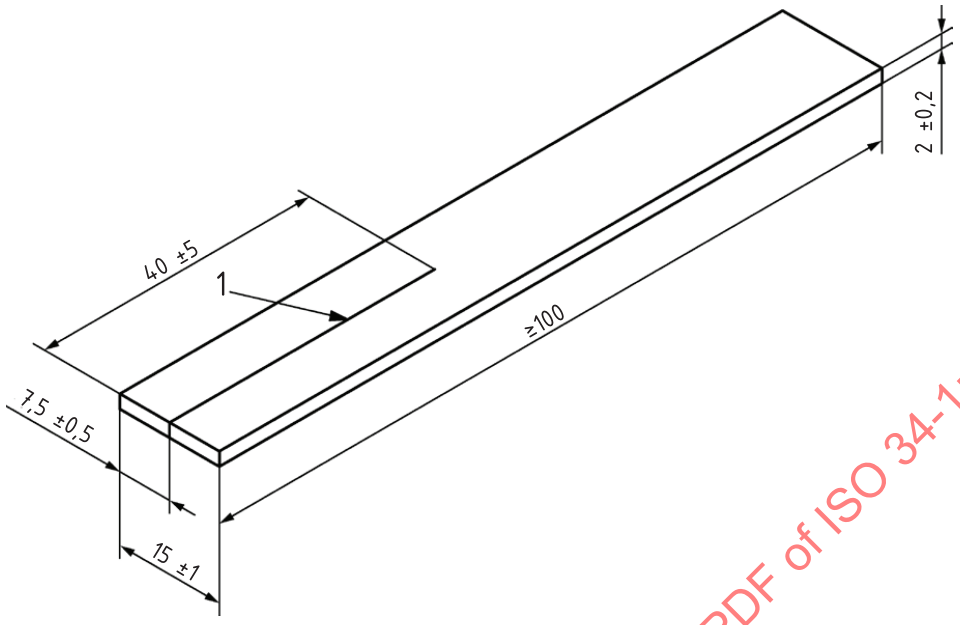
5.1.1 The die used for cutting trouser test pieces shall have the dimensions shown in Figure 1.

5.1.2 The die used for cutting angle test pieces shall have the dimensions shown in Figure 2.

5.1.3 The die used for cutting crescent test pieces shall have the dimensions shown in Figure 3.

5.1.4 The cutting edges of the dies shall be kept sharp and free from ragged edges. Care shall be taken that the cutting edges are perpendicular to the other surfaces of the die and have a minimum of concavity.

Dimensions in millimetres

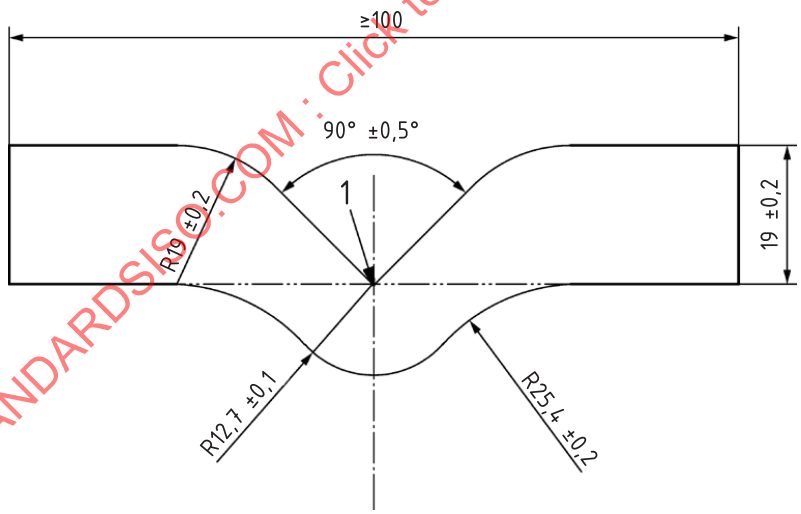


Key

1 location of cut

Figure 1 — Trouser test piece die

Dimensions in millimetres

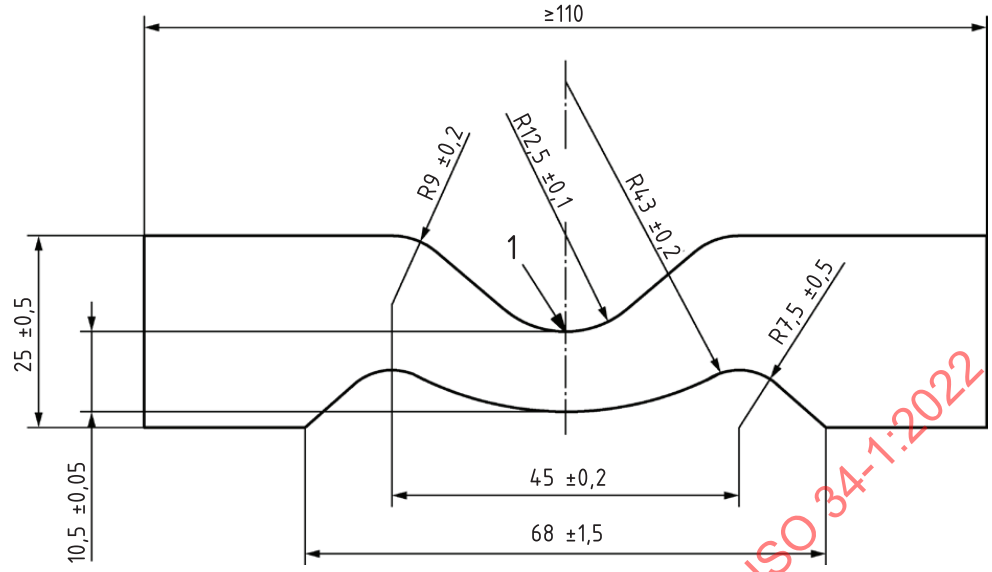


Key

1 location of nick for method B, procedure (b)

Figure 2 — Angle test piece die

Dimensions in millimetres



Key

1 location of nick

Figure 3 — Crescent test piece die

5.2 Nick cutter

A sharp razor blade or a sharp knife free from ragged edges shall be used for producing a cut or a nick in the test piece.

The apparatus for introducing the nick required for the nicked angle or crescent test piece shall be as follows.

Means shall be provided for clamping the test piece firmly, especially in the region where the nick is to be introduced. The cutting tool, consisting of a razor blade or similar blade, shall be clamped in a plane perpendicular to the major axis of the test piece, and positioned so as to introduce the nick in the appropriate place. The blade clamping device shall permit no lateral movement and shall be fitted in guides to enable the blade to be moved across the test piece with its edge remaining perpendicular to the plane of the test piece. Alternatively, the blade shall be fixed and the test piece arranged to move in an analogous manner. Means shall be provided for fine adjustment of the depth of the nick. The adjustment of the position of the blade holder or clamped test piece shall be determined for each blade by cutting one or two preliminary nicks and measuring these with the aid of a microscope. The blade shall be wetted with water or soap solution prior to nicking.

NOTE A suitable apparatus for nicking tear test pieces is described in detail in the Reference [6].

To check that the depth of the nick is within the specified limits (see 7.4), any suitable means may be used, such as an optical projection apparatus. A convenient arrangement is a microscope giving at least 10 × magnification fitted with a travelling stage suitably illuminated. The eyepiece is fitted with a graticule or crosswire by which to record the travel of the stage and test piece through a distance equal to the depth of the nick. The travel of the stage is calibrated with a stage micrometer.

Alternatively, a travelling microscope may be used.

The apparatus shall have an accuracy of measurement of 0,05 mm.

5.3 Thickness gauge

The instrument for measuring the thickness of test pieces shall be in accordance with that used in method A of ISO 23529:2016.

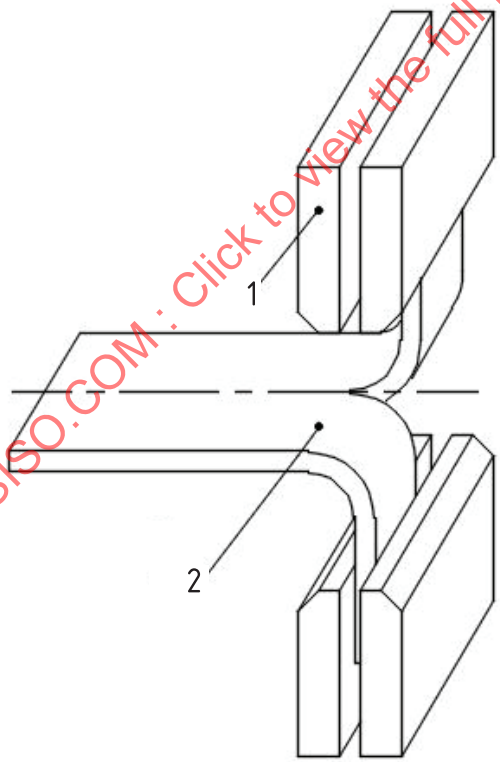
5.4 Testing machine

The machine shall conform to the requirements of ISO 5893, to an accuracy corresponding to class 1.

It shall be capable of registering the applied forces within 1 % during the test while maintaining the specified constant rate of separation of the jaws of 100 mm/min ± 10 mm/min for the trouser test piece and 500 mm/min ± 50 mm/min for the angle and crescent test pieces. A low-inertia machine having autographic force-recording facilities is essential when using the trouser test piece.

5.5 Grips

The machine shall be provided with a type of grip which tightens automatically as the tension increases and exerts a uniform pressure across the widened end of the test piece. Each grip shall incorporate a means for positioning so that the test pieces are inserted symmetrically and in axial alignment with the direction of the pull. The depth of insertion shall be such that the test piece is adequately gripped, within the parallel-sides portion, when testing angle and crescent test pieces. Trouser test pieces shall be inserted in the grips in accordance with Figure 4.



Key

1 grip

2 test piece

Figure 4 — Positioning of trouser test piece in testing machine

6 Calibration

The test apparatus shall be calibrated in accordance with the schedule given in Annex B.

7 Test piece

7.1 Test pieces shall be cut from rubber sheet of uniform thickness. Preferably, the sheet shall have a thickness of 2,0 mm ± 0,2 mm; however, it is recognized that, when sheets are prepared from finished products, this thickness cannot always be achieved.

Sheets may be moulded or prepared from products by cutting or buffing.

The requirements of ISO 23529 shall apply to the time interval between forming or preparation of the sheet and cutting of test pieces. During this interval, the sheets shall be protected from light as completely as possible.

7.2 The sheets shall be conditioned at standard laboratory temperature (see ISO 23529:2016) for at least 3 h before test pieces are cut from them.

Each test piece shall be cut from the sheet by punching with a die, shaped as shown in Figure 1, Figure 2 or Figure 3, using a single stroke of the press. The rubber shall, if necessary, be wetted with water or soap solution and shall be supported on a sheet of slightly yielding material (e.g. leather, rubber belting or cardboard) on a flat rigid surface. The test pieces shall be allowed to dry thoroughly prior to testing.

7.3 The tear strength is particularly susceptible to grain effects in the rubber. Each test piece shall, if possible, be taken in such a way that the tear strength can be determined in two directions which are at an angle of 90° to one another i.e. one at right angles to the grain and the other parallel to the grain. The directions in which the test piece is taken shall be indicated so that the effect of anisotropy can be assessed.

The direction of tear propagation is parallel to the length of the trouser test piece and perpendicular to the length of the angle and crescent test pieces.

7.4 Test pieces shall be cut or nicked to a depth as given in this subclause by the apparatus specified in 5.2.

Method A (trouser test piece) — Cut of depth 40 mm ± 5 mm made at the centre of the width of the test piece (see Figure 1). It is important that the last 1 mm (approximately) of the cut is made with a razor blade or a sharp knife.

Method B, procedure (b) (angle test piece) — Nick of depth 1,0 mm ± 0,2 mm at the apex of the internal angle of the test piece (see Figure 2).

Method C (crescent test piece) — Nick of depth 1,0 mm ± 0,2 mm at the centre of the concave inner edge of the test piece (see Figure 3).

Test pieces shall be nicked or cut, measured and then tested, preferably immediately, but if not tested immediately they shall be kept at chosen standard laboratory temperature until tested. The period between nicking or cutting of the test piece and testing shall not exceed 24 h. The cut or nick shall be made after any ageing treatment has been carried out. Unless any ageing treatment, the cut or nick shall be made immediately after the preparation of the test pieces.

8 Number of test pieces

At least five test pieces per sample shall be tested and, where possible, five from each of the directions referred to in 7.3.

9 Temperature of test

The test is normally carried out at a standard laboratory temperature, as specified in ISO 23529. When other temperatures are required, these shall be selected from ISO 23529.

If the test is to be carried out at a temperature other than a standard laboratory temperature, the test piece shall be conditioned for a period sufficient to reach substantial temperature equilibrium at the test temperature, immediately prior to testing. This period shall be kept as short as possible in order to avoid ageing the rubber (see ISO 23529).

10 Procedure

Measure the thickness of the test piece in the region in which tearing is expected to occur and in accordance with ISO 23529. No measurement on any one test piece shall deviate by more than 2 % from the median value of the thickness of that test piece. If groups of test pieces are being compared, the median thickness of each group shall be within 7,5 % of the grand median thickness of all the groups.

After conditioning as described in Clause 9, immediately mount the test piece in the testing machine (5.3) as described in 5.4. Extend the test piece at a rate of separation of the grips of 500 mm/min ± 50 mm/min for angle and crescent type test pieces and 100 mm/min ± 10 mm/min for trouser test pieces until the test piece breaks. Record the maximum force for crescent and angle test pieces. When using trouser test pieces, make an autographic recording of the force throughout the tearing process.

11 Expression of results

The tear strength T_s, expressed in kilonewtons per metre of thickness, is given in Formula (1):

$$T_s = \frac{F}{d} \tag{1}$$

where

F is the maximum force, in newtons, when using method B or C, and the median force, in newtons, calculated in accordance with ISO 6133, when using method A;

d is the median thickness, in millimetres, of the test piece.

Determine the median and the range of the values for each direction of testing.

Express the results to two significant digits.

12 Precision

See Annex A.

13 Test report

The test report shall include at least the following information:

a) sample details:

   1) full description of the sample and its origin;

   2) method of preparation of the test piece from the sample, e.g. moulded or cut;

b) test method:

   1) a full reference to the test method used, i.e. ISO 34-1:2022;

   2) test procedure used;

3) type of test piece used;

C) test details:

1) standard laboratory temperature;

2) time and temperature of conditioning prior to test;

3) temperature of test, if other than standard laboratory temperature and the relative humidity, if necessary;

4) direction of the force applied relative to the grain in the rubber;

5) for method B, whether the test piece was nicked or unnicked;

6) details of any procedures not specified in this document;

d) test results:

1) number of test pieces used;

2) median thickness of each test piece;

3) individual test results;

4) median and range of values of tear strength for each direction;

5) any special characteristics of the test pieces noted during the test and their condition after the test, e.g. direction of nick propagation;

e) date(s) of the test.

Annex A
(informative)

Precision results from an interlaboratory test programme

A.1 General

The precision calculations to provide repeatability and reproducibility values were performed in accordance ISO/TR 9272[1)], the guidance document for ISO/TC 45 test methods. Precision concepts and nomenclature are also given in ISO/TR 9272.

A.2 Precision results from the ITP

A.2.1 Programme details

The two ITP were organized and conducted by France in 1987 and 2011. For the ITP held in 1987, rubber sheets were supplied, and each participating laboratory carried out the following operations: test piece cutting, test piece nicking (if required), thickness measuring and tear strength measurement. For the ITP held in 2011, the prepared test pieces were supplied and each participating laboratory carried out the following operations: test piece nicking (if required), thickness measuring and tear strength measurement. A total of five compounds were used in the test. The samples were designated as Compounds A, B, C, D and E. For the details of the compounding of the materials and their vulcanization, see Table A.1.

Table A.1 — Compounding

Ingredient	Number of parts by mass				
	Compound A	Compound B	Compound C	Compound D	Compound E
Natural rubber	32	—	83	—	—
Smoked sheet	—	—	—	—	83
SBR 1500	68	100	17	—	—
SBR 1502	—	—	—	100	17
Carbon black	—	—	—	—	—
Type N 550	66	—	—	—	—
Type N 339	—	35	—	—	—
Type N 234	—	—	37	—	—
Type N 330	—	—	—	35	—
Type N 347	—	—	—	—	37
Aromatic oil	16	—	—	—	—
Stearic acid	1	1	2,5	1	1
Antiozonant	3	—	2,8	2	2
Zinc oxide	12	3	3	3	3
Sulfur	3,2	1,75	1,3	1,8	1,3
Accelerator	2	1	1,5	1	1,5
Hydrocarbon resin	—	—	3,5	—	—

1) Cancelled and replaced by ISO 19983.

The number of laboratories on which precision data for each property is based is given in the tables of precision results (see Tables A.2 to A.6). The number of participating laboratories as noted in these tables is the final number after identifying certain laboratory values as outliers. For the ITP held in 1987, only the total number of laboratories is known.

For both ITP, testing was conducted over a period of two sequential weeks. On a specified day in each of these four weeks, five (5) individual measurements were performed on the materials. The test result of each week is the median of the five individual measurements. All analysis was conducted on the basis of these test results.

A.2.2 Precision results

The precision results are listed in Tables A.2 to A.6.

The precision results as determined by this ITP should not be applied to acceptance or rejection testing for any group of materials or products without documentation that the results of this precision evaluation actually apply to the products or materials tested.

Explanation of symbols for Tables A.2, A.3, A.4, A.5 and A.6:

— s_r = within-laboratory standard deviation (in measurement units);

— r = repeatability (in measurement units);

— (r) = repeatability (in per cent of mean level);

— s_R = between-laboratory standard deviation (for total between-laboratory variation in measurement units);

— R = reproducibility (in measurement units);

— (R) = reproducibility (in per cent of mean level).

Table A.2 — Precision data for tear strength — Method A — Direction 1 (mill grain perpendicular)

Tear strength values in kN/m

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
A(1987)	3,68		0,91	24,7		1,29	35,0	
B(1987)	7,67		1,96	25,5		2,36	30,8	
C(1987)	22,8		8,66	38,0		13,80	60,7	
Average[b]			3,84	29,4		5,82	42,2	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 22).

[b] Simple averages calculated.

Table A.3 — Precision data for tear strength — Method A — Direction 2 (mill grain parallel)

Tear strength values in kN/m

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
A(1987)	4,81		2,32	48,3		2,61	54,3	
B(1987)	8,34		2,92	35,0		2,92	35,0	
C(1987)	27,3		11,60	42,5		13,50	49,6	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 22 for the ITP held in 1987, 14 for the ITP held in 2011).

[b] Simple averages calculated.

Table A.3 *(continued)*

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
D(2011)	3,43	0,27	0,77	22,4	0,42	1,20	35,1	14
Average[b]			4,40	37,05		5,06	43,50	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 22 for the ITP held in 1987, 14 for the ITP held in 2011).

[b] Simple averages calculated.

Table A.4 — Precision data for tear strength — Method B — Without nick

Tear strength values in kN/m

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
A(1987)	38,1		4,54	12,1		20,2	53,0	
B(1987)	44,5		7,12	15,9		20,4	45,9	
C(1987)	98,7		43,3	43,8		47,9	48,6	
D(2011)	40,9	1,22	3,46	8,46	1,40	3,95	9,67	9
Average[b]			14,61	20,07		23,11	39,29	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 25 for the ITP held in 1987, 11 for the ITP held in 2011).

[b] Simple averages calculated.

Table A.5 — Precision data for tear strength — Method B — With nick

Tear strength values in kN/m

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
A(1987)	13,2		3,90	29,4		4,74	35,7	
B(1987)	14,7		6,02	40,8		6,02	40,8	
C(1987)	62,1		29,10	49,6		37,80	60,9	
D(2011)	18,8	0,95	2,69	14,3	0,98	2,78	14,7	4
Average[b]			10,43	33,53		12,84	38,03	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 25 for the ITP held in 1987, 6 for the ITP held in 2011).

[b] Simple averages calculated.

Table A.6 — Precision data for tear strength — Method C

Tear strength values in kN/m

Compound	Mean level	s_r	r	(r)	s_R	R	(R)	No. of laboratories[a]
A(1987)	29,9		6,84	22,8		31,0	103,7	
B(1987)	31,1		4,70	15,1		29,4	94,6	
C(1987)	124,0		29,20	23,5		47,1	38,0	
E(2011)	117,2	5,78	16,4	14,0	14,7	41,5	35,4	11
Average[b]			14,29	18,85		37,25	67,93	

[a] Number of laboratories after outliers deleted (total number of laboratories in ITP: 25 for the ITP held in 1987, 13 for the ITP held in 2011).

[b] Simple averages calculated.