
Nonwovens — Test methods —

Part 18:

**Determination of tensile strength and
elongation at break using the grab
tensile test**

Nontissés — Méthodes d'essai —

*Partie 18: Détermination de la résistance à la traction et de
l'allongement à la rupture par l'essai d'arrachement par traction*

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Contents

	Page
Foreword.....	iv
1 Scope.....	1
2 Normative references.....	1
3 Terms and definitions.....	1
4 Principle.....	3
5 Reagents and materials.....	3
6 Apparatus.....	3
7 Sampling.....	4
7.1 Lot sampling.....	4
7.2 Laboratory sample.....	5
7.3 Test specimens.....	5
8 Conditioning.....	5
9 Preparation of test specimens.....	6
9.1 General.....	6
9.2 Dimensions.....	6
9.3 Marking on the test specimen.....	6
9.4 Wet test specimens.....	6
10 Preparation, calibration and verification of apparatus.....	7
10.1 Tensile testing machine.....	7
10.2 Clamping system.....	7
10.3 Verification of the total operating system of the apparatus.....	7
11 Procedure.....	8
11.1 Gauge length.....	8
11.2 Rate of extension.....	8
11.3 Mounting of test specimens.....	8
11.4 Operation.....	8
11.4.1 General.....	8
11.4.2 Slippage.....	8
11.4.3 Jaw breaks.....	9
12 Calculation.....	9
12.1 Breaking force.....	9
12.2 Apparent elongation.....	9
13 Expression of results.....	9
14 Precision and bias.....	9
15 Test report.....	9
Annex A (informative) Possible causes of low precision when grab strength testing.....	11
Bibliography.....	12

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 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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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 38, *Textiles*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 248, *Textiles and textile products*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 9073-18:2007), which has been technically revised.

The main changes are as follows:

- the title has been changed from "Determination of breaking strength and elongation of nonwoven material using the grab tensile test" to "Determination of tensile strength and elongation at breaking the grab tensile test";
- the Scope has been clarified and made precise;
- new terms have been added to the list of terms in [Clause 3](#);
- new following new Clauses have been added and subsequent clauses have been renumbered:
 - [Clause 7](#), Sampling;
 - [Clause 8](#), Conditioning;
 - [Clause 9](#), Preparation of specimens;
 - [Clause 10](#), Preparation, calibration and verification of apparatus;
 - [Clause 13](#), Expression of results;

— [Clause 14](#), Precision and bias.

A list of all parts in the ISO 9073 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.

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Nonwovens — Test methods —

Part 18:

Determination of tensile strength and elongation at break using the grab tensile test

SAFETY WARNING — This document does not claim to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. It is expected that the person performing this test has been fully trained in all aspects of this procedure.

1 Scope

This document specifies a test method for the determination of the breaking force of nonwovens using a grab method in conditioned or wet state.

This test method is not applicable to materials which have a high percentage of stretch. Comparing test results from tensile testing machines operating on different principles is not applicable.

This document specifies methods using constant rate of specimen extension (CRE) tensile testers. Constant-rate-of-loading (CRL) instruments is covered, for information, in ISO 2062:2009, Annex A, in recognition of the fact that these instruments are still in use and can be used by agreement.

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 139, *Textiles — Standard atmospheres for conditioning and testing*

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 3951-1, *Sampling procedures for inspection by variables — Part 1: Specification for single sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection for a single quality characteristic and a single AQL*

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

ISO 10012, *Measurement management systems — Requirements for measurement processes and measuring equipment*

3 Terms and definitions

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

breaking force

maximum force applied to a material carried to rupture

Note 1 to entry: Materials that are brittle usually rupture at the maximum force. Materials that are ductile usually experience a maximum force before rupturing.

3.2

maximum force

force applied to a material carried to rupture

3.3

constant-rate-of-extension tensile testing machine

CRE machine

tensile-testing machine provided with one clamp which is stationary and another clamp which moves with constant speed throughout the test, the entire testing system being virtually free from deflection

3.4

constant-rate-of-load tensile testing machine

CRL machine

testing machine in which the rate of increase of the load being applied to the specimen is uniform with time after the first 3 s

3.5

grab test

tensile test in which only the centre part of the test specimen is gripped in the jaws of the testing machine

3.6

elongation

deformation in the direction of load caused by a tensile force, generally expressed as a ratio of the length of the stretched material to the length of the unstretched material

Note 1 to entry: Elongation may be determined by the degree of stretch under a specific load or the point where the stretched material breaks.

Note 2 to entry: Elongation is expressed as a percentage.

3.7

extension

change in length of a material due to stretching

Note 1 to entry: Extension is expressed in units of length.

Note 1 to entry: See *elongation* (3.6).

3.8

grab strength testing

measuring of the “effective strength” of a fabric, i.e. the strength of fibres in a specific width together with the additional strength contributed by adjacent fibres

Note 1 to entry: Typically, grab strength is determined on a 100 mm wide strip of fabric, with the tensile load applied at the midpoint of the fabric width through 25 mm wide jaw faces that are used to clamp the fabric.

3.9

sample

product or a portion of a product taken from a production lot for testing purposes, identifiable and traceable back to the origin

3.10 test specimen

specific portion of the identified sample upon which a test is performed

Note 1 to entry: Many specimens may be tested from the same sample, using different locations.

3.11 tensile strength

resistance of a material to breaking under tension

Note 1 to entry: Tensile strength is preferably expressed in Newton.

3.12 gauge length

distance between the two effective clamping points of a testing device

Note 1 to entry: The effective clamping points (or lines) of jaws can be checked by clamping a test specimen with carbon copy paper to produce a gripping pattern on the test specimen and/or the jaw faces.

4 Principle

A test specimen, gripped in its centre part by jaws of specified dimensions, is extended at constant rate until it ruptures. The maximum force is recorded. Values for the breaking force and the elongation of the test specimen are obtained from test instrument; scales, dials, autographic recording charts, or a computer interfaced.

Comparison of results from tensile testing machines operating on different principles is not recommended. When different types of machines are used for comparison testing, constant time-to-break at (20 ± 3) s is the established way of producing data. Even then the data can differ significantly. The constant-rate-of-extension tensile testing machine is preferred for this method.

5 Reagents and materials

- 5.1 **Grade 3 water**, according to ISO 3696, for wet testing.
- 5.2 **Non-ionic wetting agent**, for wet testing.
- 5.3 **Blotting paper**, two sheets required for the test on wet test specimens.

6 Apparatus

6.1 **Tensile testing machine**, can be any of the two types of tensile tester (CRE machine and CRL machine) and their results are not comparable. In ISO 1421 and the ISO 13934 series, the CRE machine is the only one considered.

If it is necessary to describe CRE machines, these alternative methods are described for information in ISO 2062:2009, Annex A.

The metrological confirmation system of the tensile-testing machine shall be in accordance with ISO 10012.

The CRE machine shall have the general characteristics given in [6.1.1](#) to [6.1.4](#).

When different types of machines are used for comparison testing, constant time-to-break at (20 ± 3) s is the established way of producing data.

For metrological confirmation system of the tensile-testing machine, see ISO 10012 and for accuracy of the apparatus, see ISO 7500-1. The CRE machine shall have the general characteristics given in [6.1.1](#) to [6.1.4](#).

6.1.1 The tensile-testing machine shall be provided with means for indicating or recording the force applied to the test specimen in stretching it to rupture. Under conditions of use, the accuracy of the apparatus shall be class 1 of ISO 7500-1. The error of the indicated or recorded maximum force at any point in the range in which the machine is used shall not exceed ± 1 %, and the error of the indicated or recorded jaw separation shall not exceed ± 1 mm.

6.1.2 If a class 2 tensile-testing machine according to ISO 7500-1 is used, this shall be stated in the test report.

6.1.3 If recording of force is obtained by means of data acquisition boards and software, the frequency of data collection shall be at least eight per second.

6.1.4 The machine shall be capable of a constant rate of extension of 300 mm/min, with an uncertainty of measurement of ± 10 %.

6.2 Clamps and jaw faces, shall be positioned with the centre point of the two jaws in the line of applied force. The front edges shall be at right angles to the line of applied force and their clamping faces shall be in the same plane. The jaws shall be capable of holding the test specimen without allowing it to slip, so that they do not cut or otherwise weaken the test specimen.

The faces of the jaws shall be smooth, flat and metallic, or any other agreed upon gripping surface except when, even with packing, the test specimen cannot be held satisfactorily with flat-faced jaws. Then, engraved or corrugated jaws can be used to prevent slippage. Other auxiliary materials for use with either smooth or corrugated jaws to improve specimen gripping include paper, leather, plastics, or rubber.

The faces shall be parallel and have matching centres with respect to one another in the same clamp and to the corresponding jaw face of the other clamp.

For the grab test, the dimensional clamping area of the fabric shall be $25,0 \text{ mm} \pm 0,5 \text{ mm} \times 25,0 \text{ mm} \pm 0,5 \text{ mm}$. This area can be achieved by either [6.2.1](#) or [6.2.2](#).

6.2.1 One **clamp**, $25 \text{ mm} \times 40 \text{ mm}$ minimum, preferably 50 mm, positioned with the wider direction of the clamp perpendicular to the line of application of the force; a second clamp of the same dimensions is positioned perpendicular to the first so that the wider direction of the clamp is parallel to the direction of application of the force.

6.2.2 One **clamp**, $25 \text{ mm} \times 40 \text{ mm}$ minimum, preferably 50 mm, positioned with the wider direction of the clamp perpendicular to the line of application of the force; a second clamp, $25 \text{ mm} \times 25 \text{ mm}$.

6.3 Container, in which test specimens can be immersed in water preparatory to wet testing.

7 Sampling

7.1 Lot sampling

Carry out sampling in accordance with ISO 186. Ensure that the areas from which samples are taken, have no visible flaws and are not creased.

If provided in the customer specification, take random sample as directed. If no requirements are provided, use ISO 2859-1 or ISO 3951-1 and of themselves, these are not valid sampling plans by default.

An agreement between the purchaser and supplier requires taking into account process stability, producer’s risk, consumer’s risk, acceptable quality level and also the cost needs to be established.

In general, if the test characteristic can be considered normally distributed, the sampling procedures for inspection by variables requires fewer samples. However, small samples might not reflect that normal distribution and the estimated percent defective can therefore be over or underestimated. In this case, as well as for attribute data, the sampling procedures for inspection by attributes should be used.

In the absence of any sampling size requirement, the following tables can be used. Switching rules are required to maintain the AQL protection.

[Table 1](#) illustrates the inspection by attributes, while [Table 2](#) illustrates the inspection by variables.

Table 1 — Attributes (1.0 AQL, General Inspection Level II)

Number of units in the lot inclusive	Number of units that comprise the lot sample
1 to 150	13
151 to 280	32
281 to 500	50
501 to 1 200	80

Table 2 — Variables (“s” method, General Inspection Level II)

Number of units in the lot inclusive	Number of units that comprise the lot sample
1 to 15	3
16 to 25	4
26 to 50	6
51 to 90	9
91 to 150	13
151 to 280	18
281 to 500	25
501 to 1 200	35

NOTE An adequate specification or other agreement between the purchaser and supplier requires taking into account the variability between rolls of nonwoven fabric and between specimens from a swatch from a roll of material to provide a sampling plan with meaningful producer’s risk, consumer’s risk, acceptable quality level, and limiting quality level.

7.2 Laboratory sample

From each roll or portion of material taken from the lot sample, cut at least one laboratory sample the full width of the fabric and 1 m in the machine direction.

NOTE Results obtained on small hand samples can only be considered as representative of that sample, and cannot be assumed to be representative of the material portion from which the hand sample or swatch was taken.

7.3 Test specimens

Take the test specimens from areas of the sample that are free of folds, wrinkles, and any distortions that would make these specimens abnormal from the rest of the test material.

8 Conditioning

Bring samples to moisture equilibrium in the standard atmosphere for preconditioning, conditioning and testing for testing nonwovens as specified in ISO 139. Equilibrium is considered to have been reached when the increase in mass of the test specimen in successive weighing made at intervals of not

less than 2 hours does not exceed 0,25 % of the mass of the specimen. Preconditioning and conditioning are not required for tests in the wet condition.

While conditioning for a fixed time cannot be accepted in cases of dispute, it can be sufficient in routine testing to expose the material to the standard atmosphere for testing textiles for a reasonable period of time before the specimens are tested. It is recommended that samples be conditioned for at least 24 h in the relaxed state.

9 Preparation of test specimens

9.1 General

From each laboratory sample, two sets of test specimens shall be cut, one set in the machine direction and the other in the cross-machine direction.

The long dimensions of test specimens shall be parallel either to the machine direction or to the cross direction.

Each set shall consist of at least five test specimens, except that if a higher degree of precision is required, more test specimens shall be tested. No test specimens shall be cut from within 150 mm of either edge of the laboratory sample. Test specimens shall be provided diagonally.

The length of the test specimen depends on the type of clamps being used. The test specimen should be long enough to extend through the clamps and project at least 10 mm at each end.

9.2 Dimensions

The width of each test specimen shall be $100 \text{ mm} \pm 2 \text{ mm}$ and its length shall be long enough to secure the gauge length of 100 mm.

9.3 Marking on the test specimen

On each test specimen, a line shall be drawn at distance of 37 mm from one edge, parallel to machine or cross-machine direction, running the full length of the test specimen.

9.4 Wet test specimens

9.4.1 When the maximum force of the wet fabric is required in addition to the maximum force when dry, test specimens of the appropriate width and at least twice as long as the test specimens required for a dry test shall be cut. Each end of each strip shall be numbered, and then each test specimen shall be cut crosswise into two parts, one for determining the dry maximum force and the other for determining the wet maximum force. This ensures that each pair of test specimens contains the same direction. For fabrics where it is suspected or known from previous experience that excessive shrinkage will occur when wet, the length of test specimens for the determination of wet maximum force shall be greater than that of test specimens for dry maximum force tests.

9.4.2 For tests in the wet condition, immerse the test specimen for a period of 1 h in grade 3 water, in accordance with ISO 3696 at a temperature of $20 \text{ }^\circ\text{C} \pm 2 \text{ }^\circ\text{C}$. An aqueous solution containing not more than 1 g of a non-ionic wetting agent per liter can be used instead of water. A test of any test specimen shall be completed within two minutes after its removal from the water.

NOTE For tropical regions, the temperature according to ISO 139 can be applied.

10 Preparation, calibration and verification of apparatus

10.1 Tensile testing machine

10.1.1 Prepare the machine according to the manufacturer's instructions and using the conditions given in [10.1.2](#) to [10.1.3](#) (see [Annex A](#)).

10.1.2 Set the distance between the clamps (gauge length) at (75 ± 1) mm.

10.1.3 Select the force range of the testing machine for the break to occur between 10 % and 90 % of full-scale force. Calibrate or verify the testing machine for this range.

10.1.4 Set the testing machine for a loading rate of (300 ± 10) mm/min unless otherwise specified.

10.2 Clamping system

Check the jaw face surfaces for flatness and parallelism.

NOTE Some sources of clamping irregularities are surface contact, metal surface, or jaw coating-cover surface, condition, and pressure application.

10.3 Verification of the total operating system of the apparatus

- a) Verify the total operating system (loading, extension, clamping, and data collecting) by testing specimens of a standard material for breaking force and elongation and comparing that data with historical data from that same standard material. This verification of the system is recommended on daily basis before use, but at a minimum should be done on a weekly basis. In addition, the total operating system should be verified whenever there are changes in the load cells or change in grips (clamping system).
- b) Select and prepare the standard material which has breaking force and elongation in the range of interest.
- c) Check for adequacy of clamping pressure by mounting a specimen and marking the inner jaw face-to-material junctions. Break the specimen and watch for movement of either line away from the junction to indicate slippage. If slippage occurs, adjust the air pressure of pneumatic clamps or be prepared to tighten manual clamps more when testing. If pressures cannot be increased without causing jaw breaks, other techniques for eliminating slippage, such as jaw cushioning or specimen tabbing, will be necessary.
- d) Test the standard material specimens as directed in [Clause 11](#).
- e) Calculate the breaking force and elongation, the averages and the standard deviations as directed in [clause 12](#).
- f) Compare the data with previous data. If the average is outside the tolerances established, recheck the total system to locate the cause for the deviation.

NOTE Tensile tester settings:

- No pre-load.
- If applicable, return to start position at the end of test.
- Criteria for break are set to have a clear break of the test samples. (For example, a break occurs when the force has dropped to 5 % of the maximum force or use an extension value as crosshead stop of the movement.)
- Results: Maximum force/Breaking force (N), Elongation at maximum force (%), (Time to maximum force (s), where the sample breaks - acceptable or not.)

11 Procedure

11.1 Gauge length

Set the gauge length of the tensile-testing machine to 75 mm ± 1 mm for Option A, and 100 mm ± 1 mm for Option B. Take care that the specimen is centrally located and that the long dimension is as parallel as possible to the direction of force application. Be sure that the tension on the specimen is uniform across the clamped width.

Make sure the load is zero before mounting of each specimen. Carefully mount the specimen so that all the slack in the material is removed, but care should be taken so that pretension is not applied to the specimen.

NOTE Placing of the specimen into the upper and lower jaws of the tensile machine can be a large source of error in performing this method. The elongation measurement is taken from the point where the force curve leaves the zero line. Mounting the specimens carefully and methodically into the jaws can reduce some of the technician error. See [Annex A](#).

11.2 Rate of extension

Set the rate of extension of the tensile-testing machine to 300 mm/min. for Option A, and (100 ± 5) mm/min for Option B. Mark across the test specimen at the front inner edge of each jaw to check for specimen slippage. When slippage occurs, the mark will move away from the jaw edge and the results of this test specimen shall be discarded.

11.3 Mounting of test specimens

Clamp a test specimen centrally so that its longitudinal centre line passes through the centre point of the front edges of the jaws and becomes perpendicular to the edges of the jaws to have the line drawn on the test specimen coincide with one edge of the jaws. After closing the upper jaw, avoid pretension when adjusting the test specimen along the guideline in the lower jaw so that the fabric hangs under its own weight when the lower clamp is closed. Mark across the test specimen at the front inner edge of each jaw to check for specimen slippage.

When slippage occurs, the mark will move away from the jaw edge and the results of this test specimen shall be discarded.

NOTE Placing of the test specimen into the upper and lower jaws of the tensile machine can be a large source of error in performing this method. The elongation measurement is taken from the point where the force curve leaves the zero line. Mounting the test specimens carefully and methodically into the jaws can reduce some of the technician's errors. See [Annex A](#).

11.4 Operation

11.4.1 General

Mark across the test specimen at the front inner edge of each jaw to check for specimen slippage. When slippage occurs, the mark will move away from the jaw edge and the results of this test specimen shall be discarded. Engage the device for recording the maximum force. Put the movable clamp in motion and extend the test specimen to the point of rupture. Record the maximum force in newtons. Perform the test at least on five test specimens of each fabric direction.

11.4.2 Slippage

Disregard any test results where the test specimen slips asymmetrically or by greater than 2 mm along the clamping line.

11.4.3 Jaw breaks

Record any break which occurs within 5 mm of the clamping line of jaws and report the result as a jaw break. At the end of the five tests, examine the results obtained. If any of the jaw break results falls above the lowest “normal” break result, then it can be included. If any of the jaw break results falls below the lowest “normal” break result, then it shall be excluded, and further tests should be carried out to obtain five “normal” breaks.

If all the results are jaw breaks, or if five “normal” breaks cannot be obtained, then the individual results shall be reported without the coefficient of variation or confidence limits.

Jaw break results shall be indicated as such in the report, and the results discussed between the interested parties. If such a break is caused by damage to the specimen by the jaws, then the results should be discarded.

NOTE It is difficult to determine the precise reason for certain specimens to break near the edge of the jaws. If, however, the break is due merely to randomly distributed weak places, it is a legitimate result. In some cases, it may also be caused by a concentration of stress in the area adjacent to the jaws because the jaws prevent the specimen from contracting in width as the force is applied. In such cases, a break near the edge of the jaw is inevitable and it is accepted as a characteristic of the particular material and the test method.

12 Calculation

12.1 Breaking force

For each laboratory sample and testing condition, Calculate the arithmetic mean of the maximum force, in newtons, for each direction tested for all acceptable test specimens, that is, the maximum force exerted on the test specimen as read directly from the testing machine. If required, calculate the coefficient of variation to the nearest 0,1 % and the 95 % confidence limits of the relevant properties tested, rounded to the same precision as the mean values.

12.2 Apparent elongation

Unless some other force is specified, measure the apparent elongation of acceptable test specimens at the breaking force. Measure the increase in length from the start of the force-extension curve to a point corresponding with the breaking force, or other specified force. Calculate the apparent elongation as the percentage increase in length based on the gage length. Calculate the arithmetic mean of the elongation at maximum force, and, if required, at rupture, in %, for each direction tested round it to the nearest percentage point. If required, calculate the coefficient of variation to the nearest 0,1 % and the 95 % confidence limits of the relevant properties tested, rounded to the same precision as the mean values.

13 Expression of results

Calculate the arithmetic mean of the maximum force and, if required, the arithmetic mean of the breaking force, in newtons, for each direction tested.

14 Precision and bias

The precision and bias for this method is not available at the date of publication.

15 Test report

The test report shall include the following information:

- a) a reference the test method used, i.e. ISO 9073-18:2023;

- b) complete identification of all samples tested;
- c) name and address of testing institution;
- d) date of the test;
- e) make and model of testing equipment, including the type of tensile testing machine used;
- f) dimensions of the jaw faces used;
- g) measuring ranges of the load cell used to perform the test;
- h) individual test results;
- i) arithmetic mean of the breaking force for specimens giving acceptable breaks specimens (in CD and/or MD), in newton for each testing condition;
- j) arithmetic mean of the elongation at break of acceptable specimens if requested, (in CD and/ or MD), in percent for each testing condition;
- k) maximum force obtainable in the range used for testing;
- l) types of modification used in the jaws if needed;
- m) laboratory testing conditions;
- n) number of specimens tested for each condition, including number of tests rejected and reasons for this and its direction and note CD and/or MD if significant;
- o) for computer processed data, identify the software used and the version;
- p) deviation from the standard test procedure, if any;
- q) when calculated, the standard deviation or the coefficient of variation. If required, calculate the coefficient of variation to the nearest 0,1 % and the 95 % confidence limits of the relevant properties tested, rounded to the same precision as the mean;
- r) state of test specimens (conditioned or wet) and whether or not samples were conditioned prior to testing and, if so, for how long;
- s) anything unusual noted during the testing;
- t) if SI units are not used, the values shall be reported in parallel.