
Nonwovens — Test methods —

Part 3:

**Determination of tensile strength and
elongation at break using the strip
method**

Nontissés — Méthodes d'essai —

*Partie 3: Détermination de la résistance à la traction et de
l'allongement à la rupture par la méthode sur bande*

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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 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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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 9073-3:1989), which has been technically revised.

The main changes are as follows:

- the title has been changed from "*Textiles — Test methods for nonwovens — Part 3: Determination of tensile strength and elongation*" to "*Nonwovens — Test methods — Part 3 Determination of tensile strength and elongation at break using the strip method*";
- the mandatory Terms and definitions clause ([Clause 3](#)) has been added and subsequent clauses have been renumbered;
- [8.2](#) has been revised.

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.

Nonwovens — Test methods —

Part 3:

Determination of tensile strength and elongation at break using the strip method

SAFETY WARNING — This document does not claim to address all 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 and elongation of nonwovens using a strip method in conditioned or wet state. This test method describes two procedures, Option A (width of test specimen: 25 mm) and Option B (width of test specimen: 50 mm).

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 terminological 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 (3.2) applied to a material carried to rupture

3.2

maximum force

force appearing during a *test specimen* (3.11) carried to rupture in a tensile test under the specified conditions

3.3

force at rupture

force recorded at the point of rupture of a *test specimen* (3.11) during a tensile test

Note 1 to entry: See [Figure 1](#).

3.4

constant-rate-of-extension tensile testing machine

CRE tensile testing 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

3.5

constant-rate-of-load tensile testing machine

CRL tensile testing 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 seconds

3.6

elongation

ratio of the *extension* (3.9) of a *test specimen* (3.11) to its *initial length* (3.15)

Note 1 to entry: Elongation is expressed as a percentage

3.7

elongation at maximum force

elongation (3.6) of a *test specimen* (3.11) produced by the *maximum force* (3.2)

Note 1 to entry: See [Figure 1](#).

3.8

elongation at rupture

elongation (3.6) of a *test specimen* (3.11) corresponding to the *force at rupture* (3.3)

Note 1 to entry: See [Figure 1](#).

3.9

extension

increase in length of a *test specimen* (3.11) produced by a force, in this context, stretching

3.10

sample

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

3.11

test specimen

specific portion of the identified *sample* (3.10) upon which a test is performed, many specimens sometimes being tested from the same sample, using different locations

3.12**strip test**

tensile test in which the full width of the *test specimen* (3.11) is gripped in the jaws of the testing machine

3.13**tensile strength**

resistance of a material to breaking under tension

Note 1 to entry: See [Figure 1](#).

Note 2 to entry: Tensile strength is preferably expressed in Newtons.

3.14**gauge length**

distance between the two effective clamping points of a testing device

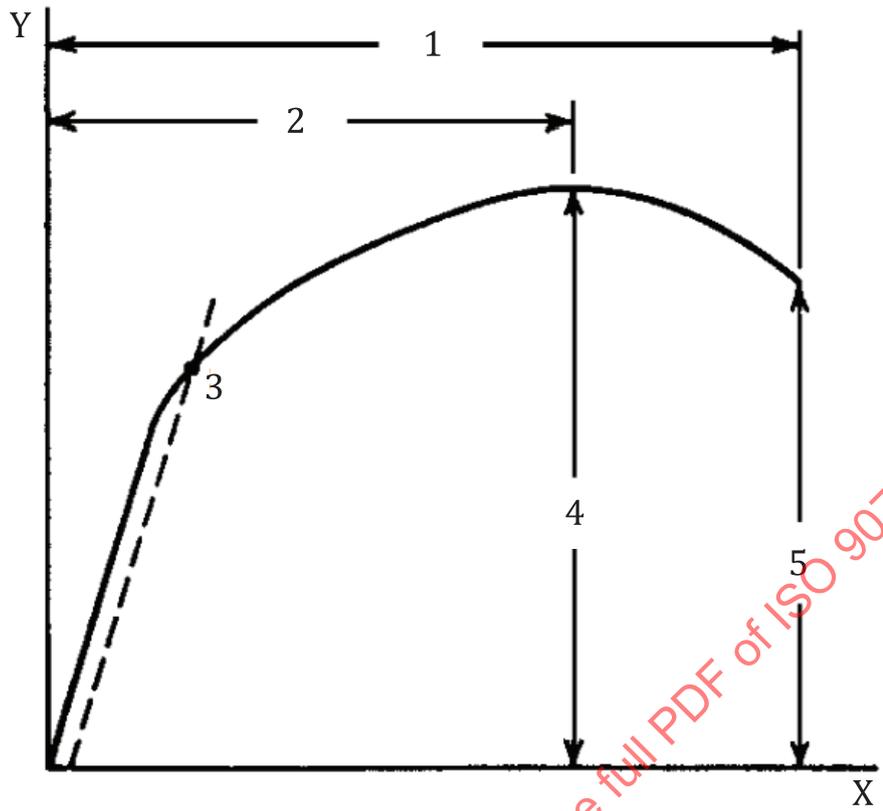
Note 1 to entry: The effective clamping points (or lines) of jaws can be checked by clamping a test specimen under defined pretension with carbon copy paper to produce a gripping pattern on the test specimen and/or the jaw faces.

3.15**initial length**

length of a *test specimen* (3.11) under specified pretension between the two effective clamping points at the beginning of certain tests

Note 1 to entry: See also [3.14](#).

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- Key**
- X conventional strain
 - Y average stress
 - 1 strain to fracture
 - 2 uniform strain
 - 3 offset yield strength
 - 4 tensile strength
 - 5 fracture stress

Figure 1 — Example of force-elongation curve

4 Principle

A test specimen of specified dimensions is extended at a constant rate until it ruptures. The maximum force and the elongation at maximum force and, if required, the force at rupture and the elongation at rupture are recorded. Values for the breaking force and elongation of the test specimen are obtained from machine scales, dials, autographic recording charts, or a computer interface.

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) seconds 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, in accordance with ISO 3696 for wetting test specimens.

5.2 Nonionic wetting agent.

5.3 Blotting paper, two sheets required for the test on wet test specimens.

6 Apparatus

6.1 Tensile testing machine (CRE or CRL)

The mechanism of the two types of tensile tester (CRE and CRL) is different (see ASTM D76) 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.

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

The constant-rate-of-extension machine (CRE machine) shall have the general characteristics given in [6.1.1](#) to [6.1.6](#).

6.1.1 The tensile-testing machine shall be provided with means for indicating or recording both the force applied to the test specimen in stretching it to rupture and the corresponding extension of the test specimen. 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 $\pm 1\%$, 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 to be used, this shall be stated in the test report.

6.1.3 If recording of force and elongation 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 constant rates of extension of 100 mm/min and 300 mm/min, with an accuracy of $\pm 10\%$.

6.1.5 The machine shall be capable of setting the gauge length to 75 mm and 200 mm, to within ± 1 mm.

6.1.6 The clamping device of the machine shall be positioned with the centre 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 and designed so that they do not cut or otherwise weaken the test specimen.

The faces of the jaws shall be smooth and flat, except that when, even with packing, the test specimen cannot be held satisfactorily with flat-faced jaws, 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.

For all strip tests, each jaw face shall measure at least 10 mm wider than the test specimen being tested and at least 25 mm in the direction of the applied force.

NOTE 1 Different jaw face surfaces can lead to different elongation results.

NOTE 2 If jaw breaks or slippage cannot be prevented with flat jaws, capstan jaws have often been found suitable. Extension measurement can be carried out by means of an extension meter which follows the movement of two reference points on the test specimen.

6.2 Clamps and jaw faces

Each jaw face shall be smooth, flat, and with a metallic, or other agreed upon, surface. 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 all strip tests, each jaw face shall measure at least 10 mm wider than the specimen being tested and at least 25 mm in the direction of the applied force.

6.3 Container

In which test specimens can be immersed in water preparatory to wet testing.

7 Conditioning

The atmospheres for preconditioning, conditioning and testing shall be as specified in ISO 139. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighing made at intervals of not less than 2 hours does not exceed 0,25 % of the mass of the specimen.

It is recommended that samples be conditioned for at least 24 h in the relaxed state.

NOTE 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.

8 Sampling

8.1 General

Carry out sampling in accordance with ISO 186. Ensuring 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, ISO 2859-1 or ISO 3951-1 shall be used. In 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 the cost needs to be established.

In general, if the test characteristic can be considered normally distributed, the sampling procedures for inspection by variables will require fewer samples. However, small samples may 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, [Table 1](#) and [Table 2](#) below can be used. Switching rules are required to maintain the AQL protection.

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

An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of material and between specimens. A sampling plan with a meaningful producer’s risk and consumer’s risk shall be provided. The plan shall justify the intended quality level.

8.2 Laboratory sample

From each roll or portion of material taken from the lot sample, cut at least one laboratory sample of 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.

8.3 Test specimens

From each laboratory sample, test five specimens from the machine direction and five specimens from the cross direction.

9 Preparation of 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.

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 as diagonally.

Narrow test specimens of material which are 50 mm or less wide are tested full width and the dimension noted on the test report.

NOTE 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 projected at least 10 mm at each end.

9.2 Dimensions

9.2.1 Option A, the width of test specimen shall be (25 ± 1) mm and its length shall be long enough to allow a gauge length of 75 mm long and the long dimension shall be parallel to the direction of testing and force application (see NOTE under [9.1](#)).

9.2.2 Option B, the width of test specimen shall be $(50 \pm 0,5)$ mm and its length shall be long enough to allow a gauge length of 200 mm. (cutting the specimen 275 mm would aide in placing the specimens into the jaws). The long dimension shall be parallel to the direction for which the breaking force is required (see NOTE under [9.1](#)).

9.3 Wet test specimens

9.3.1 When the maximum force of the wet fabric is required in addition to the maximum force when dry, strips 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 of the same number contain 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.

9.3.2 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 $20\text{ °C} \pm 2\text{ °C}$. To thoroughly wet a test specimen, it may be necessary to add not more than 1 g/l of a non-ionic wetting agent to the water.

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

10 Preparation, calibration and verification of apparatus

10.1 Tensile testing machine

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

10.1.1 Set the distance between the clamps (Gauge length), according to the option used. For option A, set the distance at (75 ± 1) mm. For Option B, set it at (200 ± 1) mm (see [9.2](#)).

10.1.2 Select the force range of the testing machine so that the break will occur between 10 % and 90 % of full-scale force. Calibrate or verify the testing machine for this range.

10.1.3 Set the testing machine constant rate of extension according to the option used. For option A, set at (300 ± 10) mm/min. For Option B, set at 100 mm/min (± 5 mm/min).

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 a 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 according to [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 200 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 or elongation of the tensile-testing machine to (300 ± 10) 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

Take care that the test 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 test 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.

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.

NOTE For most testing machines, data will be obtained using an interfaced computer.

11.4 Operation

Clamp a test specimen centrally so that its longitudinal centre-line passes through the centre point of the front edges of the jaws.

Engage any device for recording the maximum force and elongation at maximum force. Put the movable clamp in motion and extend the test specimen to the point of rupture. Record

- a) the maximum force, and, if required, the force at rupture, in newtons; and
- b) the extension in millimetres, or the elongation in percent, at maximum force, and, if required, at rupture.

11.5 Slippage

Disregard any test results where the test specimen slips asymmetrically or by greater than 2 mm along the clamping line. It is difficult to determine the precise reason for certain specimens to break near the edge of the jaws. If such a break is caused by damage to the specimen by the jaws, then the results should be discarded. If, however, the break is due merely to randomly distributed weak places, it is a legitimate result. In some cases, it can 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 should be accepted as a characteristic of the particular material and the test method.

11.6 Jaw breaks

Record any break which occurs within 5 mm of the clamping line of the jaws and record 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 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 test report, and the results discussed between the interested parties.

12 Calculation

12.1 Breaking force

For each laboratory sample and testing condition, calculate the average of the breaking force observed for all acceptable specimens, that is, the maximum force exerted on the 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 Measurement of apparent elongation

Unless some other force is specified, measure the apparent elongation of acceptable 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 gauge length.

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.

12.3 For each testing situation

Calculate the average apparent elongation at the breaking force or other specified force, of acceptable specimens.

The elongation calculated as a percentage of the gauge length for the specimen should be referred to as the apparent elongation because the actual length of fabric between the jaws is usually greater than the initial gauge length. This difference in length is frequently due to material slippage from between the jaws. Thus, elongation, calculated on the gauge length, has an error which is dependent upon the amount of slippage.

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

To express the test results, round it to the nearest whole number.

14 Precision

The precision for this method is not available at the time of publication.

15 Test report

In addition to the precise test results, the report shall include the following information:

- a) a reference to this document, i.e. ISO 9073-3:2023;
- b) test procedure number, complete identification of all tested materials and sampling method;
- c) name and address of testing institution;
- d) make and model of testing equipment;
- e) date of the test;
- f) laboratory testing conditions, including the conditioning atmosphere used;
- g) number of test specimens, including number of tests rejected and reasons for this;
- h) for computer processed data, identify the software used and the version;
- i) any deviation from the standard test procedure;
- j) when calculated, the standard deviation or the coefficient of variation;
- k) if required, the coefficient of variation and the 95 % confidence limits of the relevant force and of the relevant elongation, in percent;
- l) any unusual feature noted during the testing;

- m) average time required to break, if applicable, for all specimens giving acceptable breaks;
- n) type of tensile testing machine used;
- o) dimensions of jaw faces used;
- p) measuring ranges of the load cell used to perform the test;
- q) arithmetic mean of the force at break (in CD and/ or MD), in newtons for each testing condition;
- r) arithmetic mean of the elongation at break (in CD and/ or MD), in percent for each testing condition;
- s) maximum force obtainable in the range used for testing;
- t) types of modification used in the jaws if needed.
- u) state of test specimens (conditioned or wet);
- v) readable name and signature of the test runner.

SI values are regarded as the official standard system of measurement for this standard procedure. If other systems of measurement are used in place of SI units, their values shall be reported independently. Systems of measurement shall not be combined in any way, but shall be regarded and reported separately.

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