INTERNATIONAL STANDARD

# ISO 10319

Third edition
2015-05-15

# Geosynthetics — Wide-width tensile test

*Géosynthétiques — Essai de traction des bandes larges*



Reference number
ISO 10319:2015(E)

# Contents

Page

**Foreword** .... **iv**
**1 Scope** .... **1**
**2 Normative references** .... **1**
**3 Terms and definitions** .... **1**
**4 Principle** .... **4**
**5 Apparatus and reagents** .... **5**
**6 Test specimens** .... **5**
6.1 Number of test specimens .... 5
6.2 Preparation of test specimens .... 6
6.3 Dimensions .... 6
6.3.1 Nonwoven geotextiles, knitted geotextiles, geonets, geomats, clay geosynthetic barriers, drainage composites, and other products .... 6
6.3.2 Woven geotextiles .... 6
6.3.3 Geogrids with one axis .... 6
6.3.4 Geogrids with two axes and four axes .... 6
6.3.5 Geogrids with three axes .... 7
6.3.6 Metallic geotextile related product .... 7
6.3.7 Testing wet specimen .... 10
**7 Conditioning atmosphere** .... **11**
7.1 General .... 11
7.2 Conditioning for testing in wet condition .... 11
**8 Test procedure** .... **11**
8.1 Setting up the tensile testing machine .... 11
8.2 Insertion of the test specimen in the jaws .... 11
8.3 Installation of the extensometer .... 12
8.4 Measurement of tensile properties .... 12
8.5 Measurement of strain .... 12
**9 Calculations** .... **13**
9.1 Tensile strength .... 13
9.2 Tensile strain at tensile strength .... 13
9.3 Tensile strain at nominal tensile strength .... 13
9.4 Secant stiffness .... 14
**10 Test report** .... **14**

# 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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 221, *Geosynthetics.*

This third edition cancels and replaces the second edition (ISO 10319:2008), which has been technically revised.



# Geosynthetics — Wide-width tensile test

## 1 Scope

This International Standard describes an index test method for the determination of the tensile properties of geosynthetics (polymeric, glass, and metallic), using a wide-width strip. This International Standard is applicable to most geosynthetics, including woven geotextiles, nonwoven geotextiles, geocomposites, knitted geotextiles, geonets, geomats, and metallic products. It is also applicable to geogrids and similar open-structure geotextiles, but specimen dimensions might need to be altered. It is not applicable to polymeric or bituminous geosynthetic barriers, while it is applicable to clay geosynthetic barriers.

This International Standard specifies a tensile test method that covers the measurement of load elongation characteristics and includes procedures for the calculation of secant stiffness, maximum load per unit width and strain at maximum load. Singular points on the load-extension curve are also indicated.

Procedures for measuring the tensile properties of both conditioned and wet specimens are included in this International Standard.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

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

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

ISO 9862, *Geosynthetics — Sampling and preparation of test specimens*

ISO 10318, *Geosynthetics — Terms and definitions*

ISO 10321, *Geosynthetics — Tensile test for joints/seams by wide-width strip method*

EN 10223-3, *Steel wire and wire products for fencing and netting — Part 3: Hexagonal steel wire mesh products for engineering purposes*



## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10318 and the following apply.

**3.1**
**nominal gauge length**
initial distance, normally 60 mm (30 mm on either side of the specimen symmetrical centre), between two reference points located on the specimen parallel to the applied load direction

**3.2**
**elongation at preload**
measured increase in gauge length (mm) corresponding to an applied load of 1 % of the maximum load

Note 1 to entry: The elongation at preload is indicated as SA in Figure 1.

**3.3**
**true gauge length**
$L_0$
*nominal gauge length* (3.1) in millimetres plus the *elongation at preload* (3.2) in millimetres

**3.4**
**maximum tensile Force**
$F_{max}$
maximum tensile force obtained during a test

Note 1 to entry: The maximum load is expressed in kilonewtons (kN).

**3.5**
**tensile strain**
$\varepsilon$
increase in *true gauge length* (3.3) of a specimen during a test divided by true gauge length

Note 1 to entry: Tensile strain is expressed as a percentage of the true gauge length.

**3.6**
**tensile strain at maximum tensile load**
$\varepsilon_{max}$
*tensile strain* (3.5) exhibited by the specimen under maximum tensile load

Note 1 to entry: Tensile strain at maximum tensile load is expressed in percent.

**3.7**
**tensile strain at nominal strength**
$\varepsilon_{nom}$
strain at the guaranteed strength as defined by the manufacturer

**3.8**
**tensile secant stiffness**
$J$
ratio of tensile force per unit width to an associated value of strain

Note 1 to entry: Tensile secant stiffness is expressed in kilonewtons per metre (kN/m).

**3.9**
**tensile strength**
$T_{max}$
maximum force per unit width observed during a test in which the specimen is stretched to rupture

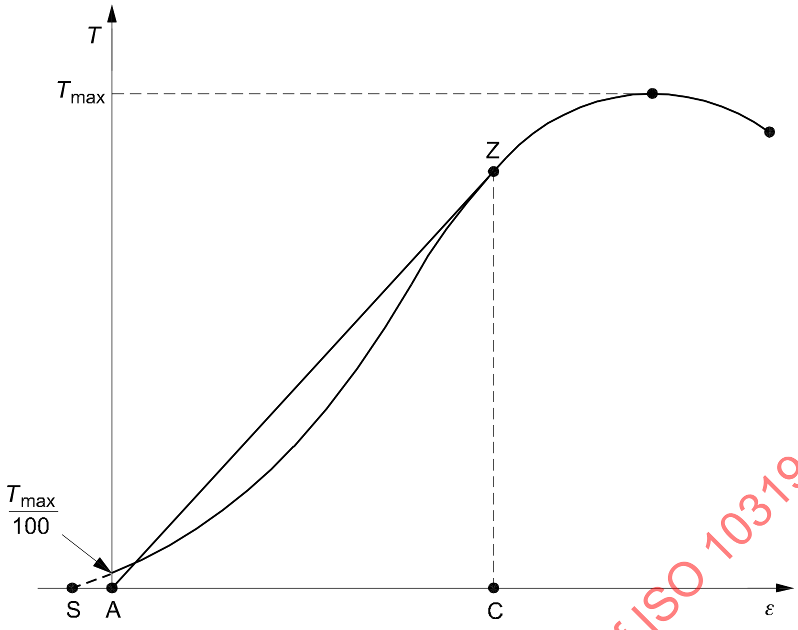
Note 1 to entry: Tensile strength is expressed in kilonewtons per metre (kN/m).

**3.10**
**strain rate**
strain at maximum load, divided by the duration of the test, i.e. the time to attainment of maximum tensile load from preload

Note 1 to entry: Strain rate is expressed in percentage per minute.



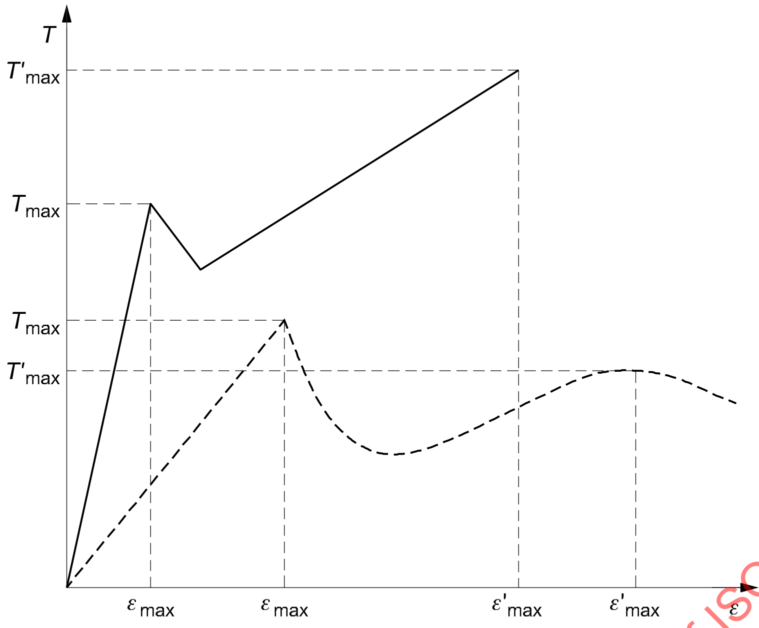
 




**Key**

| | |
|---|---|
| *T* | load/unit width, in kN/m |
| *ε* | strain, in % |
| AC | strain for secant stiffness |
| AZ | secant |
| SA | elongation at preload |

**Figure 1 — Typical load per unit width/strain curve**




**Key**

| | |
|---|---|
| $T_{max}$ | tensile strength (kN/m) |
| $\varepsilon_{max}$ | tensile strain (%) |
| $T'_{max}$ | tensile strength (kN/m) at second peak |
| $\varepsilon'_{max}$ | tensile strain (%) at second peak |

**Figure 2 — Typical tensile load per unit width — strain — curves of two geocomposites second peak-values marked by "'", e.g.** $T'_{max}$, $\varepsilon'_{max}$



## 4 Principle

A specimen is held across its entire width in a set of clamps or jaws (see Figure 3) of a tensile testing machine operated at a constant displacement speed, and a longitudinal force is applied to the test specimen until the specimen ruptures. The tensile properties of the test specimen are calculated from machine scales, dials, autographic recording charts, or an interfaced computer. A constant test speed is selected so as to give a strain rate of (20 ±5) % per minute in the gauge length of the specimen, except for products that exhibit a low strain, i.e. less than or equal to 5 %. For these products, e.g. glass, the speed is reduced so that the specimen breaks in 30 ±5 s.

The basic distinction between the current method and other methods for measuring tensile properties of fabrics is the width of the specimen. In the current method, the width is greater than the length of the specimen, as some geosynthetics have a tendency to contract (neck down) under load in the gauge length area.

The greater width reduces the contraction effect of such fabrics and provides a relationship closer to the expected fabric behaviour in the field, as well as a standard for comparison of geosynthetics.

When information on strain is required, extension measurements are made by means of an extensometer, which follows the movement of two reference points on the specimen. These reference points are situated on the specimen symmetry axis, which is parallel to the applied load, and are separated by a distance of 60 mm (30 mm on each side of the specimen symmetry centre). This distance can be adapted for some types of geogrid in order to include at least one row of nodes or internal junctions.

## 5 Apparatus and reagents

**5.1 Tensile testing machine** (constant rate of extension), complying with ISO 7500-1, Class 2 or better, in which the rate of increase of specimen length is uniform with time, fitted with a set of clamps or jaws which are sufficiently wide to hold the entire width of the specimen and equipped with appropriate means to limit slippage or damage. One clamp may be supported by a free swivel or universal joint to compensate for uneven distribution of force across the specimen.

Compressive jaws should be used for most materials, but for materials where the use of these grips gives rise to excessive jaw breaks or slippage, capstan grips may be used.

It is essential to choose jaw faces that limit slippage of the specimen, especially in stronger geosynthetics. Examples of jaw faces that have been found satisfactory are shown in Figure 3.

**5.2 Extensometer**, capable of measuring the distance between two reference points on the specimen without any damage to the specimen or slippage, care being taken to ensure that the measurement represents the true movement of the reference points.

EXAMPLE Mechanical, optical, infrared or other types, all with an electrical output.

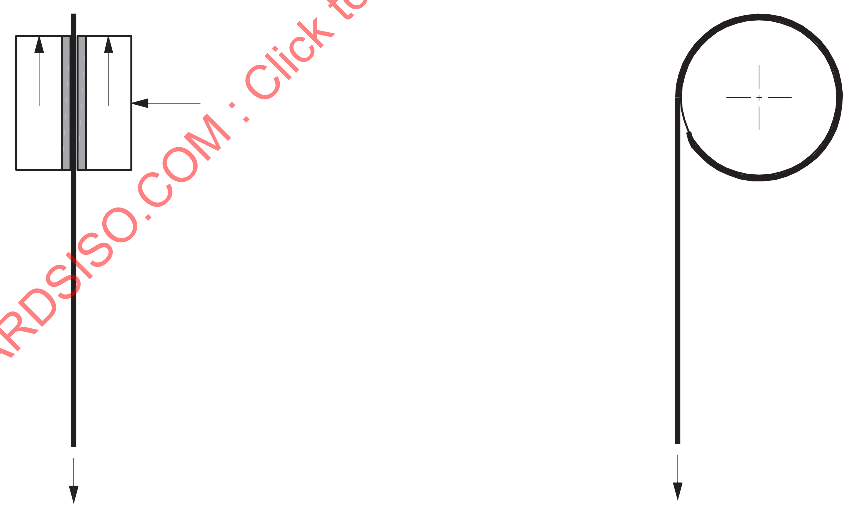
The extensometer shall be capable of measuring to an accuracy of ±2 % of the indicated reading. If any irregularity of the stress-strain curve due to the extensometer is observed, this result shall be discarded and another specimen shall be tested.

**5.3 Distilled water**, for wet specimens only, complying with Grade 3 of ISO 3696.

**5.4 Non-ionic wetting agent**, for wet specimens only.

The wetting agent used shall be a general purpose polyoxyethylene glycol alkyl ether at 0,05 % volume.





**a) friction by lateral pressure (hydraulic or mechanic)**

**b) capstan or roller clamps friction on circular tube**

**Figure 3 — Examples of jaw faces for tensile testing of geosynthetics**

## 6 Test specimens

### 6.1 Number of test specimens

Cut a minimum of five test specimens in both machine direction (MD) and cross machine direction (CMD).

## 6.2 Preparation of test specimens

Prepare the test specimens in accordance with ISO 9862.

## 6.3 Dimensions

### 6.3.1 Nonwoven geotextiles, knitted geotextiles, geonets, geomats, clay geosynthetic barriers, drainage composites, and other products

Prepare each finished test specimen to a nominal 200 mm ±1 mm width and of sufficient length to ensure 100 mm between the jaws, with the length dimension being designated and parallel to the direction in which the tensile force is applied. For some materials, the use of a cutting knife or scissors can affect the structure. In such cases, thermal cutting or other techniques can be used, and this shall be reported in the test report (see Clause 10) Where appropriate and for monitoring any slippage, draw two lines running the full width of the test specimen jaw faces, perpendicular to the length dimension and separated by 100 mm [except for capstan grips — see Figure 3b)].

### 6.3.2 Woven geotextiles

For woven geotextiles, cut each specimen approximately 220 mm wide and then make fringes by removing an equal number of threads from each side to obtain the 200 mm ±1 mm nominal specimen width.

NOTE This helps to maintain the specimen integrity during the test. When the specimen integrity is not affected, the specimens can be initially cut to the finished width.

### 6.3.3 Geogrids with one axis

For geogrids with one axis, prepare each specimen at least 200 mm wide and sufficiently long to ensure at least 100 mm between the jaws. Cut all ribs at least 10 mm from any node. Where the nodes are not separated by at least 10 mm, the specimens should be prepared two ribs wider than required for the test and, after clamping in the jaws, the outer rib on each side of the specimen should be severed. The test result (strength) shall be based on the unit of width associated with the number of intact ribs. The test specimen shall contain at least one row of nodes or cross-members, excluding the nodes of cross-members held in the jaws (see Figure 4). Products of pitch [i.e. the distance between the start of one rib (load bearing element) and the start of the next rib] less than 75 mm shall contain at least four complete tensile elements (ribs) in the width direction. Products of pitch greater than 75 mm and less than 120 mm shall contain at least two complete tensile elements in the width direction. For products of pitch greater than 120 mm, single ribs may be tested.

The reference points for the extensometer shall be marked on a central row of tensile elements that will be subjected to testing and shall be at least 60 mm apart. The reference points shall be marked at the centre point of a rib and shall be separated by at least one node or cross-member. Where necessary, the two reference points may be separated by more than one row of nodes or cross-members, in order to achieve the minimum separation of 60 mm apart. In this case, the requirement to mark the reference points at mid-rib shall be maintained and the gauge length shall then be an integral number of pitches of the grid. Measure the nominal gauge length to an accuracy of ±1 mm.

### 6.3.4 Geogrids with two axes and four axes

For geogrids with two or four axes, prepare each specimen at least 200 mm wide and sufficiently long to ensure at least 100 mm between the jaws. Cut all ribs at least 10 mm from any node. The test specimen shall contain at least one row of nodes or cross-members, excluding the nodes of cross-members held in the jaws (see Figure 5 and Figure 8).

Products of pitch less than 75 mm shall contain at least four complete tensile elements (ribs) in the width direction. Products of pitch greater than 75 mm and less than 120 mm shall contain at least two complete tensile elements in the width direction. For products of pitch greater than 120 mm, single ribs may be tested.



The reference points for the extensometer shall be marked on a central row of tensile elements that will be subjected to testing and shall be at least 60 mm apart. The reference points shall be marked at the centre point of a rib and shall be separated by at least one node or cross-member. Where necessary, the two reference points may be separated by more than one row of nodes or cross-members, in order to achieve the minimum separation of 60 mm apart. In this case, mark the reference points at mid-rib or on nodes and the gauge length shall then be an integral number of pitches of the grid. Measure the nominal gauge length to an accuracy of ±1 mm.

### 6.3.5 Geogrids with three axes

For geogrids with three axes prepare each specimen at least 200 mm wide and sufficiently long to ensure at least 100 mm between the jaws. The specimens are cut and the width of the specimen is measured as shown in Figure 6 and Figure 7.

The reference points for the extensometer shall be marked at the centre point of a node and shall be separated by at least one node or cross-member. Where necessary, the two reference points may be separated by more than one row of nodes or cross-members, in order to achieve the minimum separation of 60 mm apart. In this case, the requirement to mark the reference points at mid-rib shall be maintained and the gauge length shall then be an integral number of pitches of the grid. Measure the nominal gauge length to an accuracy of ±1 mm.

### 6.3.6 Metallic geotextile related product

For most metallic products the preparation of specimens can be done by methods already defined for geogrids

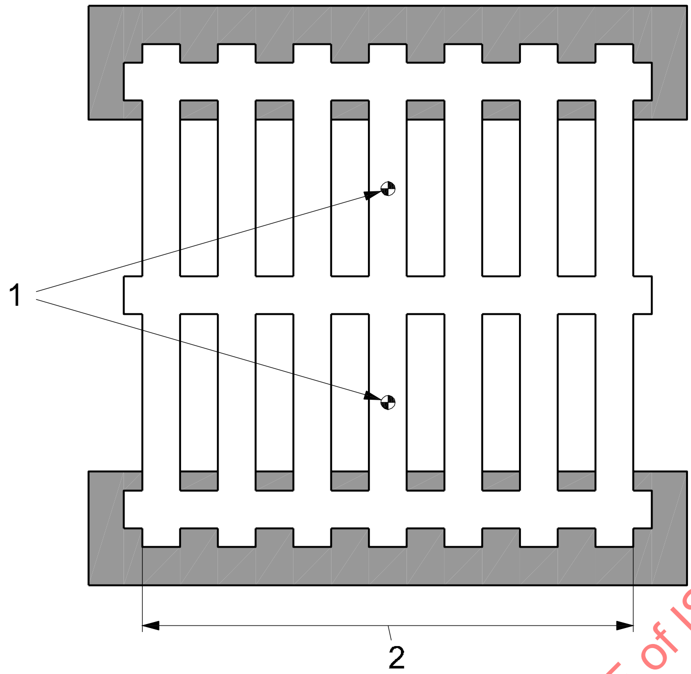
Specifically for testing double twisted, hexagonal, steel wire mesh product, the sample should be tested in accordance with EN 10223-3, except that the extension shall be measured using an extensometer.

The reference points for the extensometer shall be marked at the centre point of the double twists and shall be separated by a distance of at least 60mm. Measure the nominal gauge length to an accuracy of ±1mm (see Figure 9).

Note that results obtained in these tests might not be directly comparable to those obtained if tested in accordance with ISO 10319.



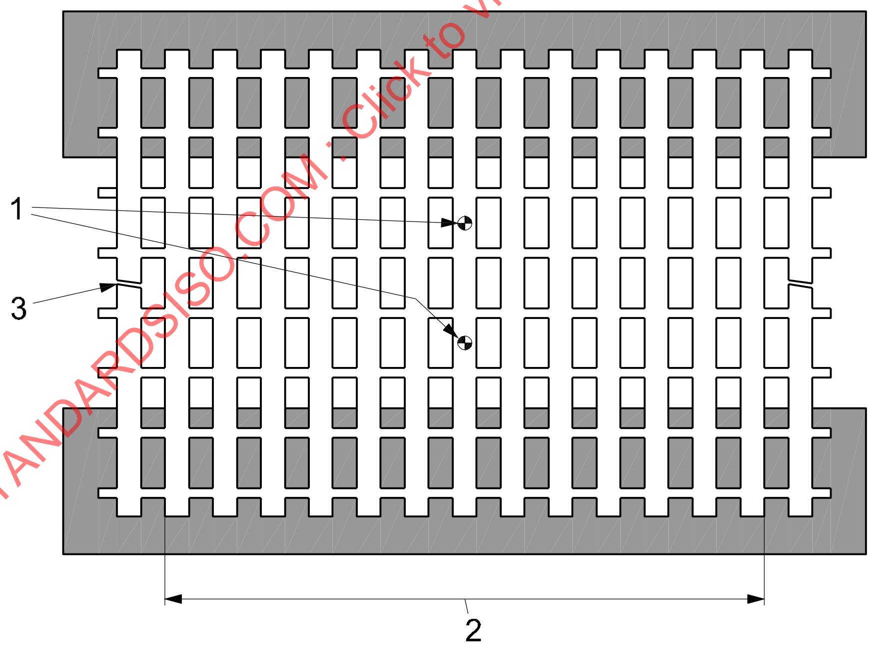



**Key**

1 gauge marks for elongation measurement ≥60 mm

2 number of load bearing elements, $n_s$

**Figure 4 — Typical geogrid with one axis**



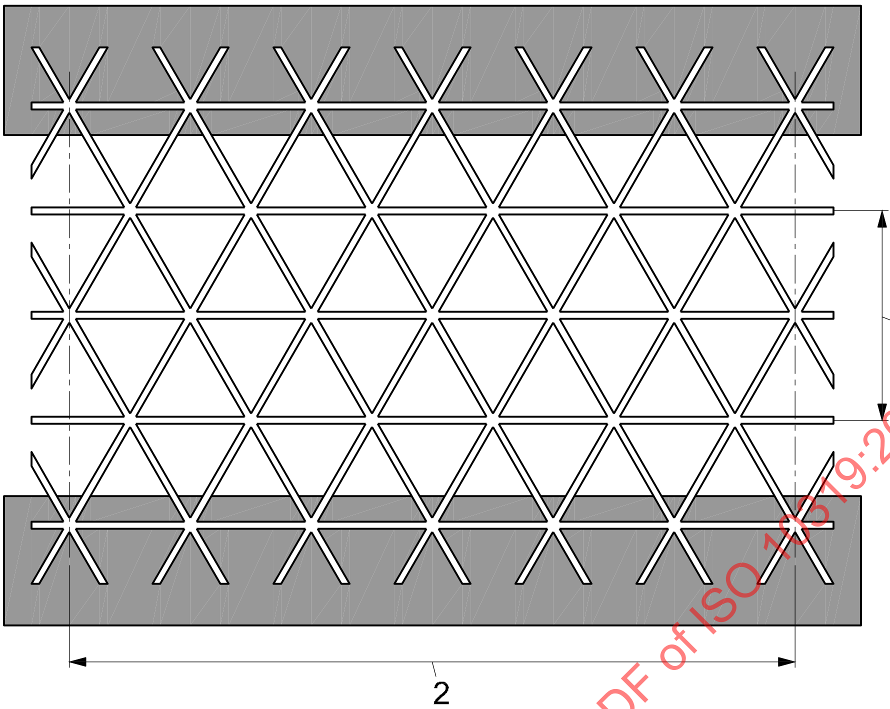

**Key**

1 gauge marks for elongation measurement ≥60mm

2 number of load bearing elements, $n_s$

3 exterior elements cut before loading

**Figure 5 — Typical geogrid with two axes**

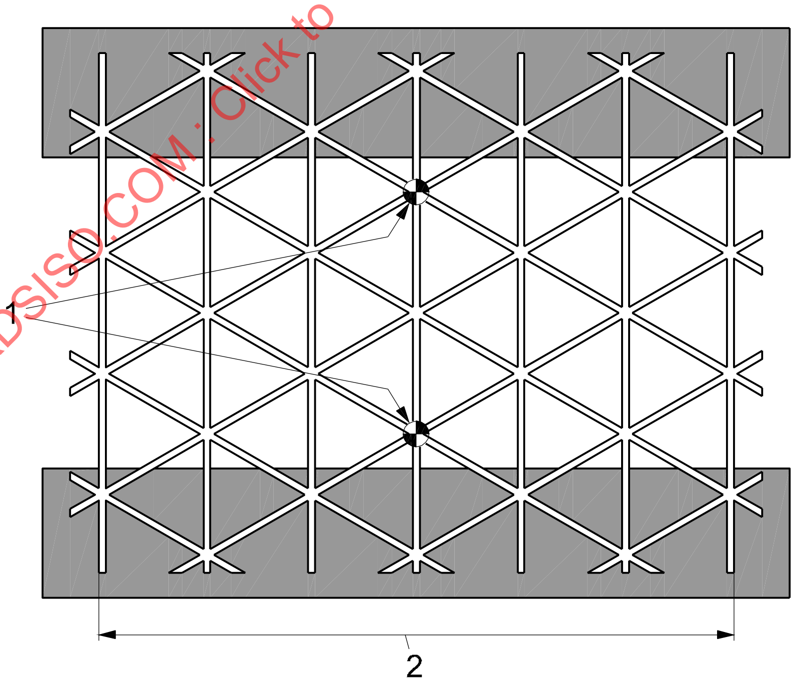



**Key**

1 gauge marks for elongation measurement ≥60mm

2 width in mm ≥ 200 mm

**Figure 6 — Example of geogrid with three axes, specimen size, widths and gauge length MD**

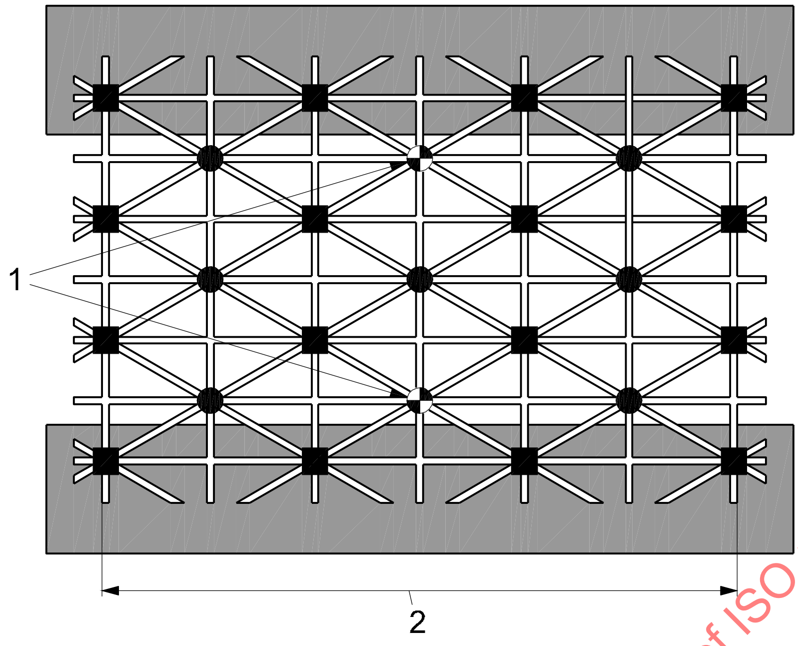



**Key**

1 gauge marks for elongation measurement ≥60mm

2 number of load bearing elements, $n_s$

**Figure 7 — Example of geogrid with three axes, specimen size, width and gauge length CMD**

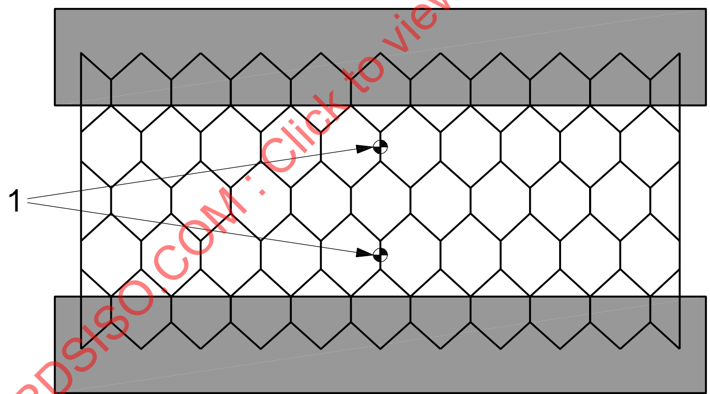



**Key**

1 gauge marks for elongation measurement >60mm

2 number of load bearing elements, $n_s$

**Figure 8 — Example of geogrid with four axes, specimen size, width and gauge length, MD and CMD**




**Key**

1 gauge marks for elongation measurement >60mm



**Figure 9 — Typical double twisted, hexagonal steel wire mesh**

If the test is to be used as a reference test for the seam/joint strength test, as described in ISO 10321, the specimen width shall be the same for both sets of tests.

### 6.3.7 Testing wet specimen

When the values of both the wet maximum load and the dry maximum load are required, cut each test specimen at least twice as long as is usually required. Number each test specimen and then cut each specimen crosswise into two halves, one for determining the dry maximum load, and the other for determining the wet maximum load. Each portion shall be marked with the specimen number. Thus, each paired break is performed on a test specimen containing the same threads.

For geosynthetics which shrink excessively when wet, the tensile strength shall be determined from the maximum load, in wet conditions, and the initial width shall be measured to an accuracy of ±1 mm, after conditioning but before wetting (see Clause 7).

# 7 Conditioning atmosphere

## 7.1 General

The test specimens shall be conditioned and tested in the standard atmosphere for testing (20 ±2 °C at 65 ±5 % RH) as defined in ISO 554.

Specimens are considered conditioned when the change in mass in successive weighing made at intervals of not less than 2 h does not exceed 0,25 % of the mass of the test specimen.

Conditioning and/or testing in a standard atmosphere may be omitted when it can be shown that results obtained for the same specific type of product (both structure and polymer type) are not affected by changes in temperature and humidity exceeding the limits. This information shall be included in the test report.

NOTE The test method is also applicable at lower or higher temperatures if values are required for such applications

## 7.2 Conditioning for testing in wet condition

Specimens to be tested in wet condition shall be immersed in water maintained at a temperature of (20 ±2) °C. The time of immersion shall be at least 24 h and shall be sufficient to wet the test specimens thoroughly, as indicated by no significant change in maximum load or strain following a longer period of immersion. To obtain thorough wetting, it may be necessary to add up to a maximum of 0,05 % of a non-ionic neutral wetting agent (5.4) to the water.

# 8 Test procedure

## 8.1 Setting up the tensile testing machine

Adjust the distance between the jaws at the start of the test to 100 ±3 mm, except for geosynthetics mounted on capstan grips and for geogrids. Select the force range of the testing machine such that the break can be measured to an accuracy of 10 N.

For geosynthetics with a strain $\varepsilon_{max}$ in excess of 5 %, set the machine at a constant cross-head speed so as to induce a strain rate of 20 ±5 % per minute in the gauge length.

For geosynthetics with a strain less than or equal to 5 %, select a speed such that the average time to break of the test specimens is 30 ±5 s.

For wet specimens, carry out the test within 3 min of removal from the water.

If capstan grips are used, the separation between the centres of the capstans at the beginning of each test shall be kept to a minimum, or for geogrids to a representative length. The use of capstan grips and the distance between the centres of the capstans shall be recorded in the test report.

## 8.2 Insertion of the test specimen in the jaws

Mount the test specimen centrally in the jaws. Ensure that, in both the machine direction and cross direction tests, the specimen length is parallel to the direction of the force applied. Where appropriate, do this by having the two lines, which were previously drawn 100 mm apart across the width of the test specimen (see 6.3.1), positioned as closely as possible adjacent to the inside edges of the jaws.

### 8.3 Installation of the extensometer

Fix the reference points on the specimen 60 mm apart (30 mm on each side of the symmetry centre of the specimen), and set the extensometer. For all geogrids see Clause 6. If a contacting extensometer is used, no damage shall be caused to the specimen. Also ensure that there is no slippage of the reference points during the test.

### 8.4 Measurement of tensile properties

Start the tensile testing machine and, using a preload of 1 % of the estimated maximum load to define the starting point for the measurement of strain, and continue running until the specimen ruptures. Stop the machine, record and report the maximum load to the nearest 10 N/m, and strain to the first decimal place; reset to the initial gauge position.

The decision to discard the results from a specimen shall be based on observation of the specimen during the test, on the inherent variability of the geosynthetic and on the provision of 5.2. In the absence of other criteria for rejecting a jaw break, any break occurring within 5 mm of the jaws, which results in a value below 50 % of the average value of all other breaks, shall be discarded. No other break results shall be discarded, unless the test is proven to be faulty.

It is difficult to determine the precise reason why certain specimens break near the edge of the jaws. If a jaw break is caused by damage to the test specimen by the jaws, the results should be discarded. If, however, it is merely due to randomly distributed weaknesses in the test specimen, 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 they prevent the test specimen from contracting in width as the load is applied. In these cases, a break near the edge of the jaws is inevitable and should be accepted as a characteristic of the particular method of test.

Special procedures are required for the testing of specimens made from specific materials (e.g. glass fibre, carbon fibre) to minimize any damage that may be caused by the jaws. If a test specimen slips in the jaws, or if more than one quarter of the specimens break at a point within 5 mm of the edge of the jaw, then:

a) the jaws may be padded,

b) the test specimen may be coated under the jaw-face area, or

c) the jaw face may be modified.

If any of the modifications listed above are used, state the method of modification in the test report.

### 8.5 Measurement of strain

Strain is the increase in true gauge length (nominal gauge length plus the increase in gauge length at preload) of a specimen during the test, expressed as a percentage of the true gauge length.

Measure the increase in true gauge length of the test specimen at any specified load by means of an extensometer.

