
**Testing method for steel tyre cord —
Part 1:
General requirements**

*Méthode d'essai pour les câbles de pneumatiques en acier —
Partie 1: Exigences générales*

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Foreword

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This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 17, *Steel wire rod and wire products*.

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Testing method for steel tyre cord —

Part 1: General requirements

1 Scope

This document specifies test methods of steel cords which are used for tyre reinforcement. Dimension, process properties, mechanical properties and coating test method are all included.

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 17832, *Non-parallel steel wire and cords for tyre reinforcement*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17832 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 <http://www.electropedia.org/>

4 Dimension

4.1 Cord diameter

4.1.1 Measure with micrometre

4.1.1.1 Principle

Hold the sample between two parallel circular faced anvils of a micrometre. Close the movable anvil gradually and gently until it is in contact with the specimen. Read the value on the micrometre.

4.1.1.2 Apparatus

4.1.1.2.1 Micrometre

A precision disk micrometre with non-rotate spindle is suggested. This micrometre may have a hole (maximum 8 mm) in the centre of the anvils (see [Figure 1](#)).

Measuring range is from 0 mm to 25 mm. Resolution is 0,001 mm.

Anvil type: the diameter of the anvils shall be greater than one lay length (min. 20 mm in diameter).
Measuring force range: <10 N. It is suggested from 3 N to 5 N.

The anvils shall be plane within 0,002 mm and parallel within 0,005 mm.

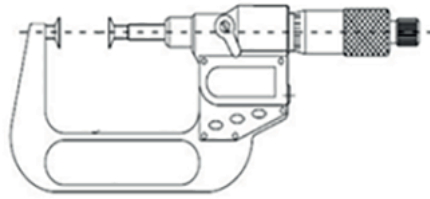


Figure 1 — Disk micrometre

4.1.1.2.2 Fusing machine

4.1.1.3 Procedure

- Clean the surface of the anvils with clean paper. Verify whether the micrometre reads 0,000 when the anvils are closed for each measurement.
- Fuse a specimen to a length about 150 mm and ensure that cord end is well secured with no unravelling. Place the sample in the centre of the anvils.
- Close the movable anvil gradually and gently until it is in contact with the specimen. For normal cords, stop rotating the spindle when 3 'click' are heard and for HE, HI and OC constructions only 1 "click" is heard.
- Axially rotate the sample between repeated measurements in order to find the maximum diameter (D_1) and minimum diameter (D_2).

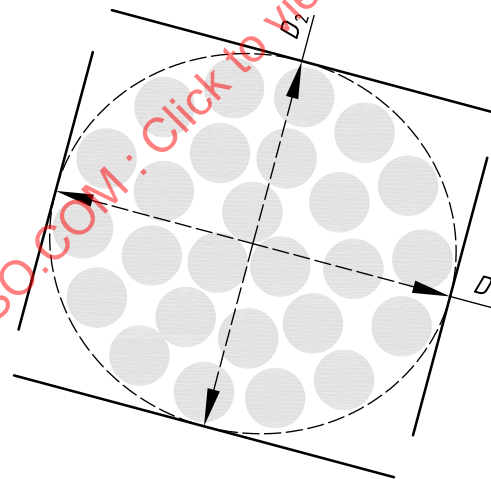


Figure 2 — Diameter test diagram

4.1.1.4 Expression of results

Calculate the average diameter (D) with [Formula \(1\)](#):

$$D = \frac{D_1 + D_2}{2} \quad (1)$$

where

D_1 is the maximum diameter, expressed in millimetres (mm);

D_2 is the minimum diameter, expressed in millimetres (mm);

D is the average diameter, expressed in millimetres (mm).

4.1.1.5 Test report

Report the average diameter to the nearest 0,001 mm.

4.1.2 Measure with profile projector

4.1.2.1 Principle

Specimens of a cord sample are successively put on the optical microscope. A silhouette of the cord is projected on the screen. The thickness of the specimen is measured by moving the abscissa axis of the projector.

4.1.2.2 Apparatus

4.1.2.2.1 Profile projector, with

- magnification possibility: $\times 10$ or $\times 20$;
- micrometre stage table: resolution 0,001 mm.

4.1.2.2.2 Sample holder, a frame on which two magnets are fixed in order to position the test specimen.

4.1.2.2.3 Fusing machine

4.1.2.3 Procedure

- a) Fuse a specimen to a length about 100 mm, ensure that fuse is securely tied in order to prevent the cord ends from any unravelling. Put the specimen on the sample holder and ensure that is fixed by magnets.
- b) Bring the sample into sample holder and adjust the focal distance. Make the sample being projected on the screen.
- c) Rotate the sample until the maximum profile is being projected on the screen. Move the micrometre table until the horizontal reference line contacts two consecutive waves (see [Figure 3](#)).

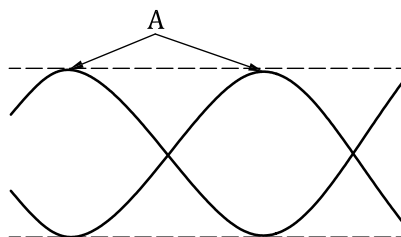


Figure 3 — X-axis contacts the two consecutive waves

- d) Reset the micrometre. Move the stage until the X-axis contacts the opposite wave (see [Figure 4](#)). Record the reading as maximum diameter (D_1). If there are two waves on the opposite side, measure the bigger one.

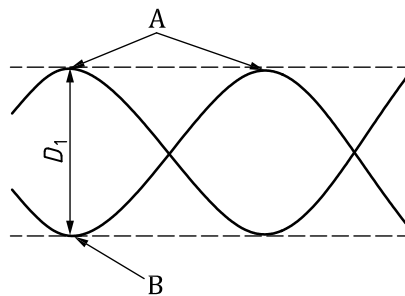


Figure 4 — X-axis contacts the other side wave

- e) Turn the specimen through 90° until a minimum diameter is obtained, record the minimum diameter D_2 . Repeat the steps c) and d) and record the reading as minimum diameter (D_2). If there are two waves on the opposite side, measure the bigger one (see [Figure 5](#)).

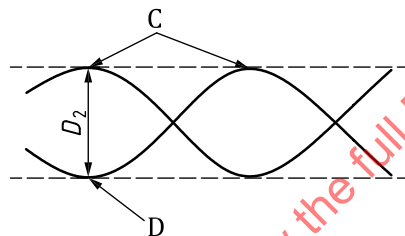


Figure 5 — Minimum diameter

4.1.2.4 Expression of results

Calculate the average diameter (D) of the two readings with [Formula \(1\)](#).

4.1.2.5 Test Report

Report the average diameter to the nearest 0,001 mm.

NOTE This test method is generally used for open cords and HI cords or for other cord types that are sensitive to radial compression when using a micrometre.

4.2 Unravalled filament diameter

4.2.1 Principle

A sample is held between two parallel blade anvils of a micrometre. The movable anvil is closed gradually and gently until it is in contact with the specimen. Read the value on the micrometre.

4.2.2 Apparatus

4.2.2.1 Blade micrometre (see [Figure 6](#))

- Measuring range is from 0 mm to 25 mm. Resolution is 0,001 mm.
- Anvil type: blade.
- Measuring force: <10 N. It is suggested from 3 N to 5 N.

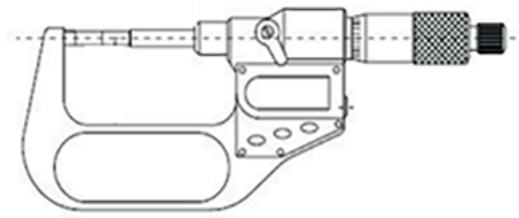


Figure 6 — Blade micrometre

4.2.2.2 Nipper pliers

4.2.3 Procedure

- Clean the surface of the anvils with clean paper. Verify whether the micrometre reads 0,000 when the anvils are closed for each measurement.
- Cut the wire approximately 100 mm in length. Position the specimen in the centre of the anvils.
- The movable anvil is closed gradually and gently until it is in contact with the specimen. Read the value after 3 'click' are heard.
- Measure on the same section of the specimen until the maximum diameter (D_1) and minimum diameters (D_2) are found.

4.2.4 Expression of results

Calculate the average diameter (D) of the two readings with [Formula \(2\)](#):

$$D = \frac{(D_1 + D_2)}{2} \quad (2)$$

where

D_1 is the maximum diameter, expressed in millimetres (mm);

D_2 is the minimum diameter, expressed in millimetres (mm);

D is the average diameter, expressed in millimetres (mm).

4.2.5 Test report

Report the average diameter to the nearest 0,001 mm.

4.3 Linear density

4.3.1 Principle

A straight section of the cord of a predefined length, generally 1 m, is weighted using an analytical balance.

4.3.2 Apparatus

4.3.2.1 Analytical balance, which can be read to the nearest 0,001 g.

4.3.3 Procedure

- a) Fuse a specimen approximately 1 200 mm in length. Cut into $(1\ 000 \pm 1)$ mm, and make sure the cord is straightened before cutting.

NOTE For normal construction, the pretension is 10 N $\pm$ 1 N, for HE/HI/OC constructions, the pretension is 2 N $\pm$ 0,5 N.

- b) Verify the balance, coil the sample and weigh it, record the mass as linear density.

4.3.4 Test report

Report the linear density to the nearest 0,001 g/m.

4.4 Lay direction and lay length

4.4.1 Lay direction/direction of lay

4.4.1.1 Principle

Hold the cord vertically and verify whether the filaments or strands around the central axis are having an “S” direction or “Z” direction.

4.4.1.2 Procedure

The cord, strand or wrap has an “S” or left-handed lay if, when held vertically, the spirals around the central axis of the cord or strand conform in direction of the slope to the central portion of the letter “S”; and “Z” or right-handed lay if the spirals conform in direction of the slope to the central portion of the letter “Z” (see [Figure 7](#)).



Figure 7 — Illustration of the S and Z direction of lay

4.4.1.3 Test report

Report the direction of lay as “S” or “Z”.

4.4.2 Trace method for lay length

4.4.2.1 Principle

Through the impacted trace of the wire, calculate the lay length by measuring the distance of multiple lay length.

4.4.2.2 Apparatus

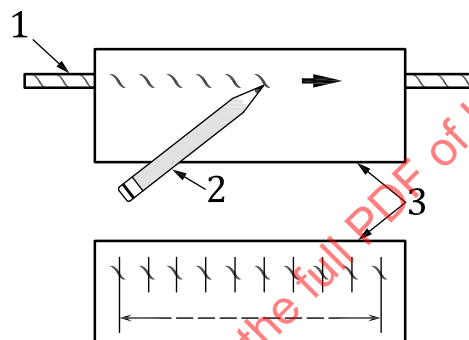
4.4.2.2.1 Pencil

4.4.2.2.2 Paper

4.4.2.2.3 White paper or carbon paper, Vernier calliper (which can be read to the nearest 0,5 mm).

4.4.2.3 Procedure

- Fuse a specimen of cord approximately 300 mm in length. Place the specimen on the clean and flat table.
- Place a sheet of white paper or carbon paper over a straight-length section of the specimen and rub the paper with a pencil to form a relief impression (see [Figure 8](#)).



Key

- sample with wrap wire
- pencil
- white paper

Figure 8 — Trace method for lay length test

- Measure the distance between the first and eleventh node on the impression.

4.4.2.4 Expression of results

Calculate the lay length with [Formula \(3\)](#):

$$L_L = \frac{L}{10} \quad (3)$$

where

L_L is the lay length, expressed in millimetres (mm);

L is the distance between the first and eleventh node, expressed in millimetres (mm).

4.4.2.5 Test report

Report the lay length to the nearest 0,01 mm.

NOTE The trace method is usually used to measure the lay length of wrap wire.

4.4.3 Untwisting method for lay length

4.4.3.1 Principle

A specified length of specimen of cord or strand is untwisted until the elements to be determined are parallel. The length of lay can be calculated by the specified length divided by the untwisted turns.

4.4.3.2 Apparatus

4.4.3.2.1 Lay length tester, whose gauge length is (500 ± 1) mm.

4.4.3.3 Procedure

- a) Place a straight specimen in the lay length tester being clamped in such a manner that no slippage will occur. The specimen shall be placed under a tension just enough to keep the specimen straight, but no more than 20 N. If the cord has a wrap then this filament shall be cut in the middle of the specimen and near each jaw and removed.
- b) Set the counter at zero. The twist is removed by turning the rotatable clamp until the components of the external layer of the specimen are complete separated. These components shall be parted with a needle or the blade of a spatula (starting at the non-rotatable clamp and moving to the rotatable clamp) to avoid the entanglement of components and to confirm that all the twist has been removed. The number of revolutions is recorded as n_1 .
- c) If the multiple layers construction and the lay length of core strand need to be measured, the operation as described above shall be repeated without unloading the cord. The number of turns to untwist this filament is recorded as n_2 .
- d) The above procedure is then repeated if necessary.

4.4.3.4 Expression of results

Calculate the lay length with [Formulae \(4\)](#), [\(5\)](#) and [\(6\)](#):

$$L_{L1} = \frac{500}{n_1} \quad (4)$$

$$L_{L2} = \frac{500}{n_2} \quad (5)$$

$$L_{L3} = \frac{500}{n_3} \quad (6)$$

where

500 is the gauge length of lay length tester. For M x N constructions, after untwisting the first layer of the cord, there is a change in length of the remaining elements, the gauge length should be decided through consultation by the buyer and seller;

L_{L1} is the layer length of the outer layer, expressed in millimetres (mm);

L_{L2} is the lay length of the second strand, expressed in millimetres (mm);

L_{L3} is the lay length of the third core strand, expressed in millimetres (mm);

- n_1 is the revolution number of the outer layer when untwist;
 n_2 is the revolution number of the second layer when untwist;
 n_3 is the revolution number of the third layer when untwist.

4.4.3.5 Test report

Report the lay length to the nearest 0,01 mm.

5 Process property

5.1 Straightness

5.1.1 Principle

Keep the cord at natural status, the position of the cord between two parallel straight lines, which are a prescribed distance apart, is observed, the cord shall be considered straight, when it is not touching the lines.

5.1.2 Apparatus

5.1.2.1 Spool mounting device, enabling the spool to rotate freely on a horizontal axis.

5.1.3 Procedure

Without cutting the specimen from the spool, pull out a 6 m length of cord (or other length agreed upon between the buyer and seller) and position it, residual torsion free and with no tension applied, between the two parallel straight lines which are 75 mm apart.

The cord shall be considered straight when not touching the lines.

5.1.4 Test report

Report the straightness as to whether or not the cord is straight.

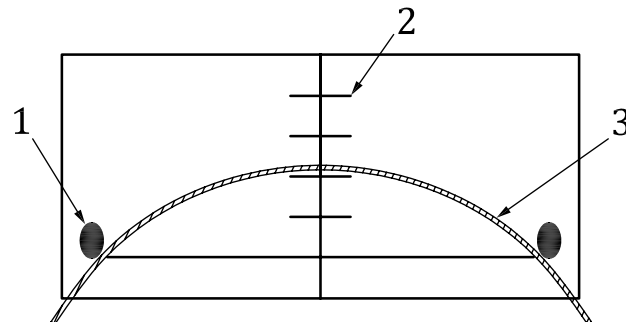
5.2 Arc height

5.2.1 Principle

Verification of the deviation from straightness of a cord by measuring the arc height over a defined cord length.

5.2.2 Apparatus

5.2.2.1 Arc height tester; the distance between two centres of pins is 300 mm. The maximum diameter for pin is 5 mm. The scale on the tester shall be read to the nearest 1 mm. Use the arc height device between 0° and 15° starting from the horizontal position (see [Figure 9](#)).



Key

- 1 pin
- 2 scale
- 3 specimen

Figure 9 — Arc height tester

5.2.3 Procedure

- a) Fuse a specimen if approximately 400 mm in length.
- b) Put the specimen gently on the planar support of the arc height tester. Keep the specimen nature arc.
- c) Read the value of the arc height on the scale in mm at the outer side of the cord arc.

5.2.4 Test report

Report the arc height to the nearest 1 mm.

5.3 Flare

5.3.1 Principle

The spreading of the filament or strand ends is observed after cutting the cord or strand and the unravelled length is measured.

5.3.2 Apparatus

5.3.2.1 A suitable pair of cutters giving a clean, right angle cut

5.3.2.2 Ruler

5.3.3 Procedure

- a) Hold the cord, cut a straight section of cord at a right angle to the axis of the sample. The cutting area shall be 10 mm to 100 mm away from the held position.
- b) Without disturbing the cut end, the most unravelled length shall be measured to the nearest 1 mm.

- c) When the unravelled length is larger than the strand lay length, there is flare. Otherwise not.

5.3.4 Test report

Report flare or no flare. Also flare in mm can be reported if the customer requests it.

5.4 Residual torsion

5.4.1 Principle

Number of revolutions per specified length of cord is counted when it is allowed to turn freely.

5.4.2 Apparatus

5.4.2.1 Spool mounting device, enabling the spool to rotate freely on a horizontal axis.

5.4.3 Procedure

- The sample shall be taken tangentially from the spool placed on the rotating mounting device. Discard the first 6 m by cutting off. Keep the sample end firmly to prevent rotation.
- Make a right-angle bend (upward movement) of about 50 mm from the end of the cord on the spool. This bend shall be held tightly to prevent rotation while pulling off a specimen having a length of 6 m.
- Then the free bent end of the cord is released and allowed to rotate while the cord is free of external tension and friction.
- Count the number of rotations of the cord end to the nearest one-fourth rotation. Denote clockwise rotating direction as (+) and anti-clockwise as (-) (see [Figure 10](#)).

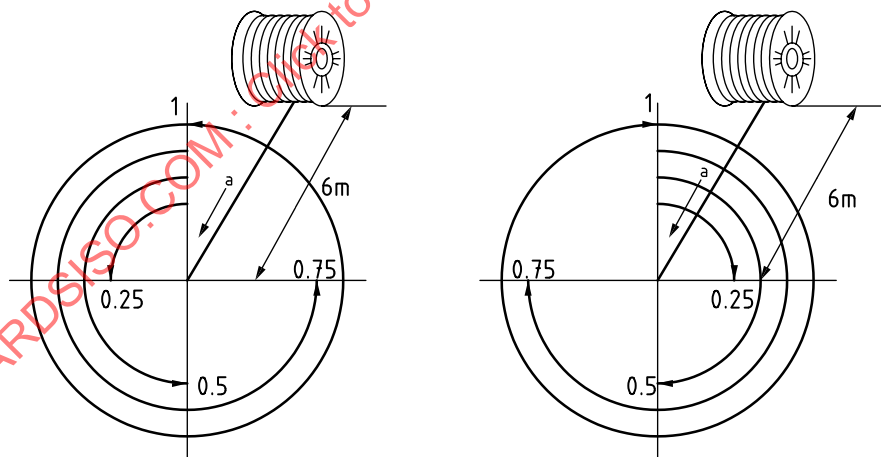


Figure 10 — Residual torsion test

5.4.4 Test report

Report the direction of rotation and the number of rotations of the cord to the nearest 1/4 turn expressed in number of turns per 6 metres.

6 Mechanical property

6.1 Breaking load and elongation at fracture

6.1.1 Principle

A specimen of cord is clamped in a tensile testing apparatus under a defined pretension and subjected to a constant rate of extension until rupture. Breaking force and nominal extension at rupture are read from the curve or from system data. Elongation at rupture is expressed in percent and is the extension at rupture divided by the specimen length, times 100.

6.1.2 Apparatus

6.1.2.1 Tensile test machine, a constant rate of extension (CRE) type with an autographic force-extension recorder.

6.1.2.2 Force sensor/force scale/load cell, the accuracy shall be more than 1 %. Select the force sensor based on the estimated breaking force of the specimen so that the test machine will be operating in the range from 1 % to 90 % of its full-scale force.

6.1.2.3 Clamps (see [Figure 11](#)), pneumatic wire tyre cord curved clamp with smooth jaw face.

6.1.2.4 Extensometer (optional), this may be any device that can be attached to the specimen and that permits recording of the specimen elongation during loading.

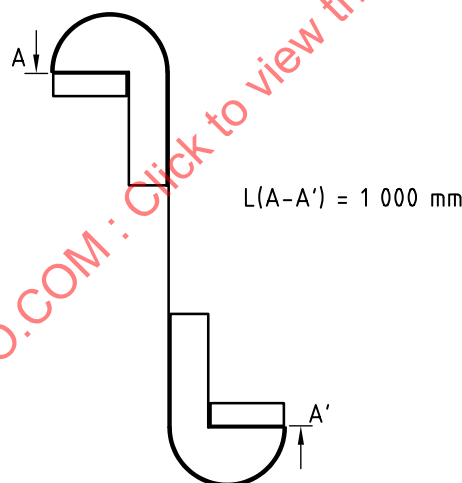


Figure 11 — Curved clamp

6.1.3 Procedure

- Install the wire tyre cord curved clamp and adjust the gauge length ($AA' = 1\,000\text{ mm} \pm 2\text{ mm}$). If the extensometer is used, the gauge length between the clamps of the extensometer could be 200 mm.
- Reset the displacement and load.
- The rate of extension is normally set at 100 mm/min for normal cords and 50 mm/min for HE/HI cords. If the extensometer is used, the rate of extension is set at maximum 50 mm/min.
- Remove the spiral wrap, if present, from the length of the specimen in contact with the clamp. Secure the specimen in the top clamp, exerting enough pressure to prevent the cord from slipping when loaded. Place the other end of the specimen between the jaws of the bottom clamp. Apply a

pretension as low as possible to keep the specimen taut. Tighten the bottom clamp. The pretension for normal cord shall be 5 N, for HE/HI cords is 3 N.

- e) Start the tensile tester and operate until the specimen breaks. Observe if there is specimen slippage during test process, if yes, check the clamps and adjust the air pressure acted on the jaws.
- f) If the maximum force for any specimen is less than the specified minimum and the specimen fractures at the gripping point or on the clamp surface, discard that result and test another specimen. If the maximum force attained meets the specified minimum, retain the result whether or not the specimen breaks at the gripping points or on the clamp surface.

If failure at the gripping point or on the clamp surface is a problem, it is suggested to insert an abrasive cloth as a jaw liner between the specimen and the jaw surface or tape the abrasive cloth to cover the full jaw gripping surface.

NOTE Abrasive cloth, 180 or 240 grits.

- g) Record the maximum force.
- h) Record the elongation at fracture.
- i) Elongation at fracture tested with curved clamps and measured from cross beam generates lower elongation level due to friction between cord and clamp surface.
- j) A correlation factor from cross beam level to extensometer level can be installed.

6.1.4 Test report

Report the breaking force to the nearest 1 N.

Report the elongation at fracture to the nearest 0,01 %.

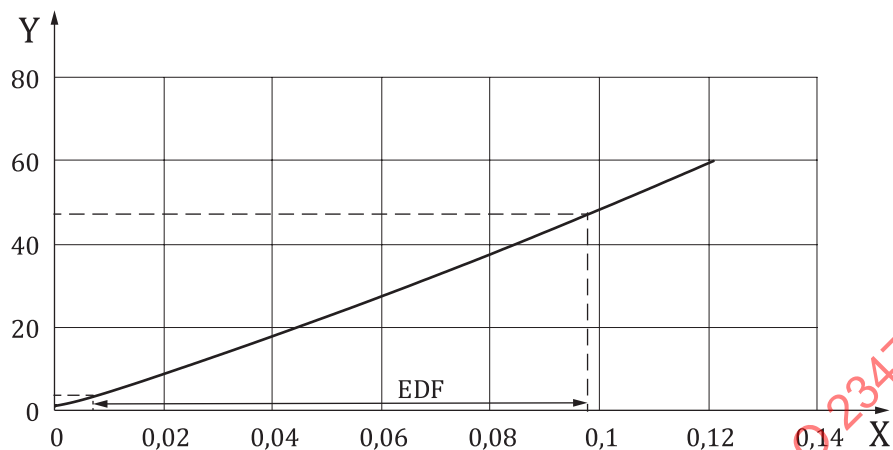
6.2 Elongation between defined forces (EDF)

6.2.1 Principle

A specimen is mounted between the clamps of a tensile testing machine (usually with a specified pretension) and then elongated until the force on the specimen has reached a given value, usually less than 50 % of the nominal breaking force of the specimen. The change in force is measured as a function of the increase in the separation of the clamps of the tensile testing machine to define a force-extension curve. The extension between two specified force points is read directly from the curve or determined by electronic means or with an on-line computer. Recommended force points are 2,5 N and 50 N. Elongation between defined forces (EDF) is expressed in percent and is the extension between two points divided by the specimen gauge length, multiplied by 100.

6.2.2 Apparatus

6.2.2.1 Tensile test machine, a constant rate of extension (CRE) type and equipped with an autographic force-extension recorder (see [Figure 12](#)).



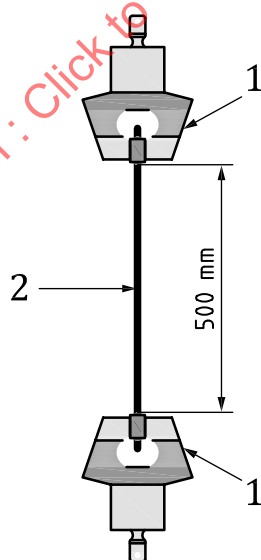
Key

X strain in %

Y force in N

Figure 12 — Force-extension graph

6.2.2.2 Clamp (see [Figure 13](#)), any clamp featuring smooth jaws which prevents slippage without causing specimen breakage.



Key

1 clamp

2 specimen

Figure 13 — Clamp