International Standard 1184

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Plastics — Determination of tensile properties of films

Plastiques — Détermination des caractéristiques en traction des films

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1184 was developed by Technical Committee ISO/TC 61, *Plastics*, and was circulated to the member bodies in October 1978.

It has been approved by the member bodies of the following countries:

Australia	Germany, F. R.	Poland
Austria	Greece	Romania
Belgium	Hungary	South Africa, Rep. of
Brazil	India	Spain
Bulgaria	Iran	Sweden
Canada	Israel	Switzerland
China	Italy	Turkey
Czechoslovakia	Japan	United Kingdom
Egypt, Arab Rep. of	Korea, Rep. of	USA
Finland	Netherlands	USSR
France	New Zealand	

No member body expressed disapproval of the document.

This International Standard cancels and replaces ISO Recommendation R 1184-1970, of which it constitutes a technical revision.

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Plastics — Determination of tensile properties of films

1 Scope and field of application

1.1 This International Standard specifies a method for determining the tensile properties of film or sheeting less than 1 mm thick in the form of standard test specimens, tested under defined conditions of pretreatment, temperature, humidity and speed of testing.

1.2 Different speeds of testing are specified to suit the different materials to which the method is applicable. It is not possible to make valid comparisons between the results of tensile tests if the rates of straining are different.

1.3 The method may not be suitable for determining the tensile properties of reinforced films and cellular sheet and film.

2 References

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 4591, *Plastics — Film and sheeting — Determination of the average thickness of a sample and average thickness and yield of a roll by gravimetric techniques (Gravimetric thickness).*

ISO 4593, *Plastics — Film and sheeting — Determination of thickness by mechanical scanning.*

3 Significance

3.1 This method may provide data for quality control, for acceptance or rejection in accordance with the terms of specifications and for research and development.

3.2 Tensile properties may vary with type of test specimen, test specimen preparation, speed of testing and environment of testing. Consequently, when precise comparative results are required, these factors must be carefully controlled.

3.3 The sensitivity of plastic materials to rate of straining and environmental conditions necessitates testing over a broad load-time scale and range of environment if tensile properties are to be used for engineering design purposes.

4 Definitions

For the purpose of this International Standard the following definitions apply:

4.1 tensile stress (nominal): The tensile force per unit area of the original cross-section within the gauge length carried by the test specimen at any given moment.

4.2 tensile strength (nominal): The maximum tensile stress (nominal) sustained by the test specimen during a tension test (see 12.6).

4.3 tensile stress at break: The tensile stress that occurs at break of the test specimen.

4.4 yield stress: The tensile stress at which occurs the first marked inflection of the stress-strain curve. Where any increase in strain occurs without any increase in stress, this point is taken as the yield stress (see figure 1, curve A).

4.5 offset yield stress: The tensile stress on the stress-strain curve where the curve departs from initial linearity by a specified strain (see 12.7).

4.6 gauge length: The original length between the gauge marks of the test specimen over which the change of length is determined.

4.7 strain: The ratio of the change in the distance between the gauge marks to the original distance.

4.8 percentage elongation: The elongation produced in the gauge length of the test specimen by a tensile stress, expressed as a percentage of the gauge length.

4.9 percentage elongation at yield: The elongation produced in the gauge length of the test specimen at the yield stress, expressed as a percentage of the gauge length.

4.10 percentage elongation at break or at maximum load: The elongation at break or at maximum load produced in the gauge length of the test specimen, expressed as a percentage of the gauge length.

4.11 proportional limit: The greatest stress that a material is capable of sustaining without any deviation from proportionality of stress to strain (Hooke's law).

4.12 elastic modulus in tension; Young's modulus: The ratio of tensile stress to corresponding strain below the proportional limit. The stress-strain relationship of many plastics does not conform to Hooke's law throughout the elastic range, but deviates therefrom even at stresses well below the yield stress. For such materials, the slope of the tangent to the stress-strain curve at a low strain is usually taken as the elastic modulus.

4.13 secant modulus: In general, the ratio of stress to strain at any given point on the stress-strain curve (see 12.9). For the tensile testing of film, the secant modulus is determined at the point on the load-elongation curve corresponding to 1 % elongation (1 % secant modulus).

5 Apparatus

5.1 Testing machine

The tensile testing machine shall be power-driven and capable of maintaining the appropriate rate of grip separation as specified in clause 9. The testing machine shall be equipped with the following devices:

5.1.1 Grips for holding the test specimen, one being attached to a fixed or stationary member of the machine and the other to a movable (power-driven) member.

The grips shall be self-aligning in that they are attached to the machine in such a way that they move freely into alignment as soon as any load is applied so that the long axis of the test specimen coincides with the direction of pull through the centre line of the grip assembly (see 10.2). The test specimen shall be held in such a way that slip relative to the grip is prevented as far as possible and this shall preferably be effected with the type of grip which maintains or increases pressure on the test specimen as the force applied to the test specimen increases. The clamping system shall not cause premature fracture at the grips.

5.1.2 Load indicator incorporating a suitable load-indicating mechanism capable of showing the total tensile load carried by the test specimen when held by the grips. This mechanism shall be essentially free from inertia lag at the specified rate of testing and shall indicate the load with an accuracy of at least 1 % of the actual value (see 12.1).

5.2 Extensometer

If an extensometer is used for determining the distance between the gauge marks on the test specimen at any time during the test, it is desirable, but not essential, that this instrument should automatically record this distance (or any change in it) as a function of the stress on the test specimen. The instrument shall be essentially free from inertia lag at the specified speed of testing and shall be calibrated to ensure that the error does not exceed 1 % of the actual strain. When an extensometer is attached to the test specimen, care must be taken to ensure that any distortion of or damage to the test specimen is minimal and it is essential that there be no slippage between the extensometer and the test specimen (see 10.3).

5.3 Devices for measuring width and thickness of the test specimens

For measuring thickness, measuring devices complying with the requirements in ISO 4593 shall be used, except for very thin film (under 0,01 mm thick) or embossed film, in which cases the thickness shall be determined by the method specified in ISO 4591. When the latter method is used, the average thickness of the film sample shall be taken as the thickness of the test specimen.

Means of measuring width with an accuracy of at least 1 % shall be used.

6 Test specimens

6.1 The preferred form of test specimen for the determination of tensile properties by this method is a strip, 10 to 25 mm wide and not less than 150 mm long, cut from the test material.

Gauge marks, at least 50 mm apart, shall be marked on the centre portion of the test specimen using ink or other medium that does not affect the material being tested. Gauge marks shall not be punched, scratched or impressed upon the test specimen (see 6.6).

6.2 When required by the specification for the material under test or for routine quality control tests, dumb-bell specimens of the form and dimensions shown in figures 2 and 3 may be used. These specimens are convenient to produce and facilitate rapid testing for quality control.

Gauge marks as shown in figures 2 and 3 shall be marked on the specimen using ink or other medium that does not affect the material under test. Gauge marks shall not be punched, scratched or impressed on the test specimen (see 6.6).

6.3 The test specimens described in 6.1 shall be cut or punched so that the edges are smooth and free from notches; examination with a low power magnifier is recommended to check freedom from notches. Razor blades, suitable paper cutters, drawing cutters or other devices capable of cutting the test specimens to the proper width and producing straight, clean, parallel edges with no visible imperfections shall be used. Punch dies shall be kept sharp by regular honing and a suitable backing material shall be used with punch dies to ensure a clean cut edge. Discard any test specimen with obvious imperfections on the cut edges.

6.4 The test specimens described in 6.2 shall be obtained by the use of punch dies, using suitable backing material to ensure a clean cut edge. Dies shall be kept sharp by regular honing and the edges of the test specimen shall be examined with a low power magnifier to ensure freedom from notches. Discard any test specimen with obvious imperfections on the cut edges.

6.5 The properties of certain types of film materials may vary with direction in the plane of the film (anisotropy). In such cases, it is essential to prepare two groups of test specimens with their major axes respectively parallel and perpendicular to the direction of some feature of the film which is either visible or inferred from knowledge of the method of its manufacture.

The direction of testing shall be the direction of the long axis of the test specimen unless otherwise stated.

6.6 A marker shall be used to apply the gauge marks. This shall have two parallel knife edges which are ground smooth and true, 0,05 mm to 0,10 mm wide at the edge and bevelled at an angle of not more that 15°. Use a stamp and an ink that has no deleterious effect on the film being tested and is of a suitable contrasting colour.

The distance between the gauge marks shall be accurate to within ± 1 %.

7 Number of test specimens

7.1 A minimum of five test specimens shall be tested in each of the required directions of testing, cut from positions approximately evenly spaced across the width of the sample.

7.2 Parallel-sided specimens (see 6.1) that slip in the grips and/or break in the grips shall be discarded and further specimens tested.

7.3 Dumb-bell specimens (see 6.2) that do not break between the parallel portion shall be discarded and further specimens tested.

7.4 Test specimens that break at some obvious flaw shall be discarded and further specimens shall be tested.

8 Conditioning

Unless otherwise specified, the specimens shall be conditioned and tested in accordance with ISO 291, using "atmosphere 23/50" except that when a material is known not to be sensitive to humidity "atmosphere 23" may be used.

9 Speed of testing

9.1 The speed of testing is the rate of separation of the grips of the testing machine during a test (see 12.2).

9.2 The speed of testing shall be chosed from one of the following:

- Speed A: 1 mm/min ± 50 %
- Speed B: 2 or 2,5 mm/min ± 20 % (see 12.3)
- Speed C: 5 mm/min ± 20 %
- Speed D: 10 mm/min ± 20 %
- Speed E: 20 or 25 mm/min ± 10 % (see 12.3)
- Speed F: 50 mm/min ± 10 %
- Speed G: 100 mm/min ± 10 %
- Speed H: 200 or 250 mm/min ± 10 % (see 12.3)
- Speed I: 500 mm/min ± 10 %

The speed selected shall be that required by the specification for the material being tested. If the speed is not specified, the lower speeds are generally used for rigid and semi-rigid materials, and the higher speeds for non-rigid materials.

9.3 Whenever possible, the same speed shall be used to determine both stress and stress-strain data up to the point of yield and/or break. However, in some cases (see 12.4), it may be necessary or desirable to adopt one speed for the determination of the stress-strain properties up to the yield point and to use a higher speed of testing for the measurement of ultimate tensile strength and elongation. In such cases, separate specimens shall be used for each testing speed.

9.4 If the modulus of elasticity in tension is being determined, the preferred speed of testing is A or B. It is desirable that the selected speed of testing give a strain rate as near as possible to 1 % of the initial distance between the gauge marks per minute.

Elastic modulus determinations shall be made with separate specimens from those used to determine other tensile properties whenever the speeds of testing are not the same.

10 Procedure

10.1 Determine the mean width and mean thickness of the test specimen (see 5.3). The width of the central parallel portion of dumb-bell specimens may be taken as the mean width of the corresponding part of the die, based on measurements taken at periodic intervals.

10.2 Mount the test specimen in the grips of the testing machine so that the axial alignment coincides with the direction of pull. Tighten the grips uniformly and firmly to prevent the specimen from slipping, but not to the extent that the test specimen is damaged.

10.2.1 For the specimens described in 6.1, clamp the test specimen so that the distance between the grips of the testing machine is 100 mm and the gauge marks are centrally disposed between the grips (see 12.5).

10.2.2 For the dumb-bell specimens described in 6.2, clamp the specimen so that the initial distance between the grips of the testing machine is dimension l_2 in figures 2 and 3.

10.3 If applicable, set and adjust a calibrated extensometer to the gauge length of the test specimen before application of stress. The specimen shall not carry the weight of the extensometer (see 5.2).

10.4 Set the speed of testing to the specified value and start the machine. Note and record some or all of the following information:

a) the force and corresponding deformations at appropriate and approximately even intervals of strain in the region of elastic behaviour or until the specified strain is reached (it is preferable to use an automatic recording system for this operation);

b) the force at the yield point;

c) the distance between the gauge marks at yield, at maximum load and at break (see 12.8);

d) the force at the specified distance between the gauge marks;

e) the force at break and/or maximum load (see 12.6);

f) the force at the conventional yield limit.

10.5 When the elastic modulus is being determined, the preferred speed of testing is A or B (see 9.4). Follow the procedure of 10.4.1. The secant modulus may be obtained from the load-elongation curve so obtained.

11 Calculation and expression of results

11.1 Calculate the tensile stress at yield and/or the maximum tensile stress and/or the tensile stress at break and/or at the offset yield point on the basis of the original cross-sectional area of the test specimen, by the equation

$$\sigma = \frac{F}{A}$$

where

σ is the tensile stress, in megapascals, at yield and/or break and/or maximum load and/or offset yield point;

F is the force, in newtons, at yield and/or break and/or maximum load and/or offset yield point;

A is the initial cross-sectional area, in square millimetres, of the test specimen.

NOTE — The tensile force per unit width may be determined in place of tensile stress, by agreement between the interested parties.

11.2 Calculate the percentage elongation at yield and/or break on the basis of the original gauge length, by the formula

$$\frac{l - l_0}{l_0} \times 100$$

where

l is the distance, in millimetres, between the gauge marks at yield or break;

l_0 is the original gauge length, in millimetres.

11.3 Calculate the elastic modulus E_m, expressed in megapascals, on the basis of the initial linear portion of the load-elongation curve, from the expression

$$E_m = \frac{\text{Difference in stress between two points on the straight line drawn tangent to the initial portion of the curve}}{\text{Difference in strain between the same two points}}$$

where the stress and strain are as defined in clause 4.

11.4 Calculate the offset yield stress from a measurement of stress at the point of intersection of the stress-strain curve and the line drawn parallel to the initial linear part of the curve (see figure 1), by the equation

$$\sigma_{os} = \frac{F_{os}}{A}$$

where

σ_{os} is the offset yield stress, in megapascals, at the point indicated;

F_{os} is the force, in newtons, applied at this point;

A is the initial minimum cross-sectional area, in square millimetres, of the test specimen.

11.5 Calculate the secant modulus from the measurement of stress at a given level of strain of magnitude 0,01 (see 12.9), by the equation

$$E_{1\,\%} = \frac{\text{Stress}}{\text{Strain}} = \frac{F_e}{0{,}01\,A}$$

where

$E_{1\,\%}$ is the 1 % secant modulus, in megapascals;

F_e is the force required to produce a strain of magnitude 0,01, in newtons;

A is the initial mean cross-sectional area, in square millimetres.

11.6 Calculate tensile stress and modulus values to three significant figures. Calculate percentage elongation values to two significant figures.

11.7 Calculate the arithmetic mean of each five test results and, if required, the standard deviation and 95 % confidence interval of the mean value by the procedure given in ISO 2602.

12 Notes

12.1 Attention is drawn to the fact that different force-measuring systems have markedly different characteristics. In particular, pendulum type machines may have high friction and inertia which will significantly affect their dynamic response. Inertialess transducer types of machines are therefore to be preferred.

Although tensile machines fitted with electronic force-measuring devices can be regarded as being sufficiently free of inertia lag for the speeds of testing given in this International Standard, this does not necessarily apply to the recorders used with them.

As a guide to recorder requirements, the response time for full-scale travel (t_e) should be considerably less than the rise time of the force (t_w), if the dynamic errors are to be comparable with the static inaccuracy. It is recommended that $t_w > 10\,t_e$.

For a full-scale response, the relationship with the testing speed would be

$$100\, v_M = \frac{l_0\, E_p}{t_w} \leqslant \frac{l_0\, E_p}{10\, t_e}$$

where

v_M is the testing speed, in millimetres per minute;

l_0 is the grip or gauge mark separation, in millimetres;

E_p is the percentage elongation corresponding to the maximum force;

t_e and t_w are the times, in minutes and fractions of a minute.

If only a fraction (δ) of full-scale deflection is involved, the permissible maximum testing speed is increased to v_m, which is given approximately by the relationship

$$v_m = \frac{1}{\delta} \times v_M$$

When evaluating the inertia of the tensile testing machine, it is recommended that the time to reach the yield or the break point (whichever is the sooner) should be a minimum of 30 s.

12.2 On some testing machines, the grip attached to the load-recording mechanism may itself move a significant distance during the test and thereby influence the applied rate of strain. It is suggested that where the movement of the load-recording mechanism during a test is less than 0,5 mm, then it may be neglected. For movements greater than 0,5 mm, the movement should be taken into account in calculating the applied rate of strain.

12.3 At the present time, both speeds are commonly used throughout the world. For the time being, both are being allowed for the purpose of this International Standard.

Subsequent revisions of the International Standard may only incorporate one testing speed for each of the speeds B, E and H.

12.4 This may apply when the material has a pronounced yield and extends a large amount beyond the yield point before rupture. If such materials are tested up to the point of rupture at a slow speed that has been selected primarily to produce initial stress-strain data, the test will become unnecessarily prolonged and indeed, in certain circumstances, be invalid. The testing of some highly extensible materials may fall into this category.

12.5 Some film materials have a very high elongation at break which may bring them outside the stretching capacity of the testing machine. In such cases it is permissible to reduce the initial distance between the grips to 50 mm and reduce the gauge length in proportion.

12.6 When testing test specimens showing considerable reduction in cross-sectional area before break, the force may decrease to some extent after having reached a maximum value, so that the maximum force and the force at break are not the same.

12.7 In cases in which the yield stress is not well defined by the stress-strain curve, it is necessary to define an offset yield stress. This is done by specifying a point on the stress-strain curve where the curve departs from linearity by a specified strain (see figure 1, curve B).

12.8 If strain data are required at or beyond the point of yield, the yield must take place within the gauge length.

12.9 When secant modulus is used, the relationship between stress and strain need not be linear below the strain at which the modulus is taken.

13 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) complete identification of the material tested, including type, source, manufacturer's code number, form, principal dimensions and previous history;

c) the type of the test specimen used, method of cutting, principal dimensions and the direction of the principal axes of the test specimens on which the test was performed;

d) the standard atmosphere used for conditioning and testing and any preconditioning treatment;

e) number of specimens tested;

f) the speed of testing;

g) the mean value of the required tensile properties;

h) the individual test results;

j) the standard deviation and 95 % confidence interval of the mean value (if required).

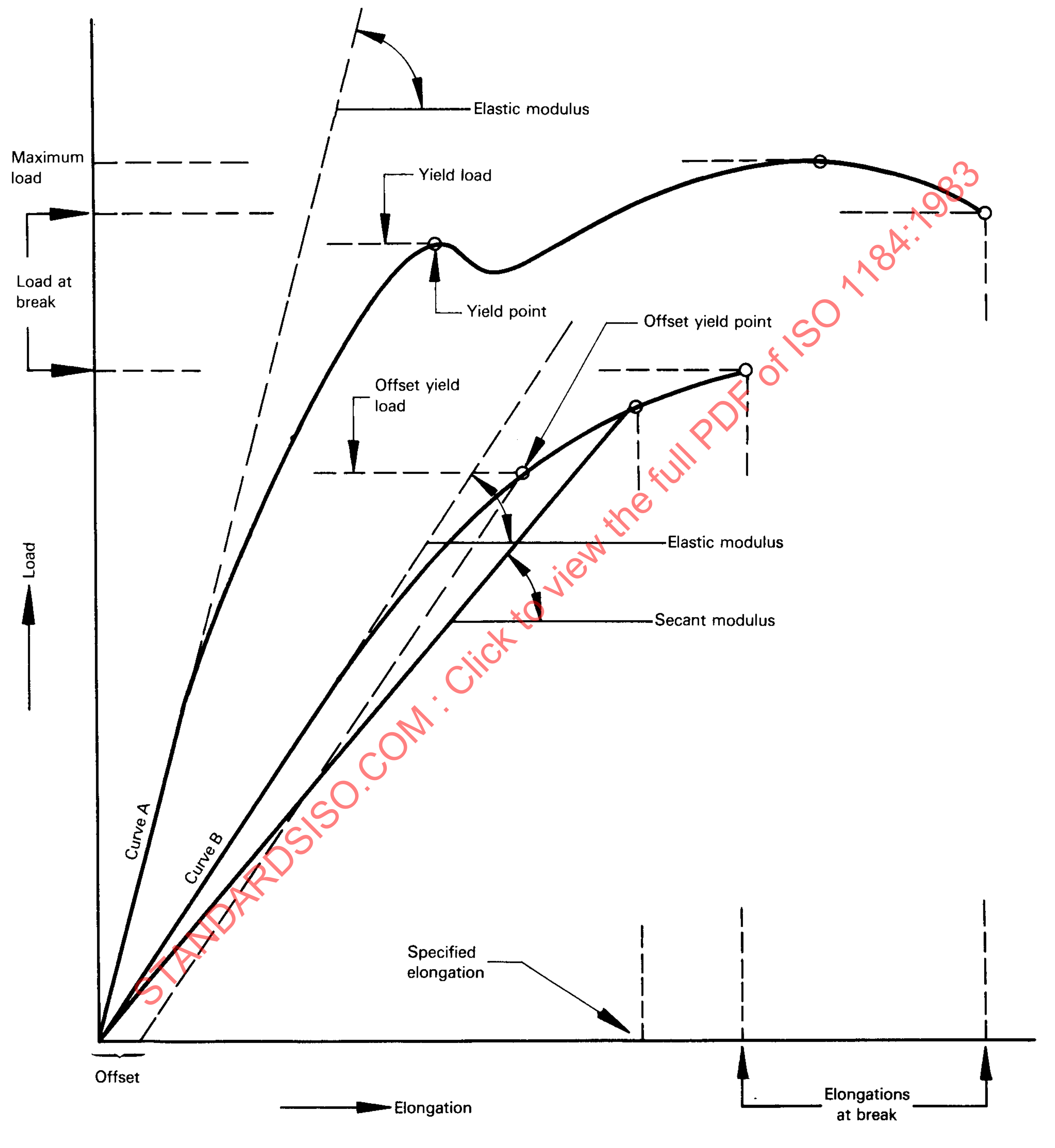
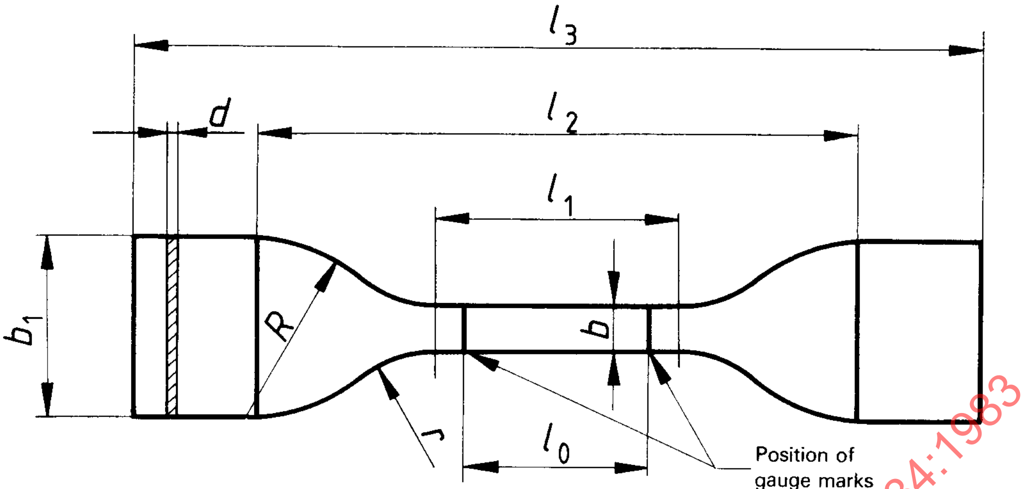


Figure 1 — Typical load-elongation (stress-strain) curves

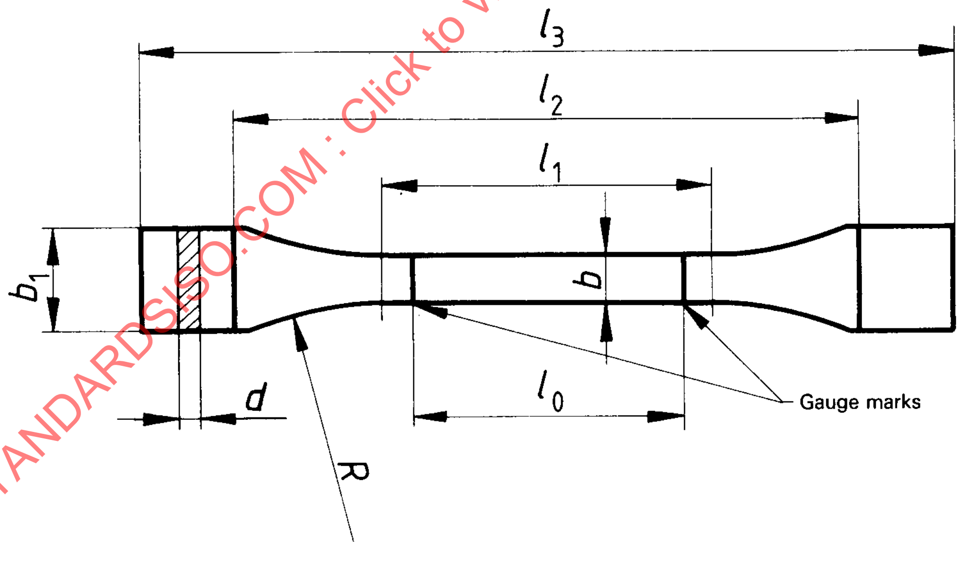


Dimensions in millimetres

l_3 Overall length, min. : 115
b_1 Width at ends : 25 ± 1
l_1 Length of narrow parallel portion : 33 ± 2
b Width of narrow parallel portion : 6 ±0,4
r Small radius : 14 ± 1

R Large radius : 25 ± 2
l_0 Distance between gauge marks : 25 ± 0,25
l_2 Initial distance between grips : 80 ± 5
d Thickness (see 5.3 and 10.1)

Figure 2 — Dumb-bell specimen



Dimensions in millimetres

l_3 Overall length, min. : 150
b_1 Width at ends : 20 ± 0,5
l_1 Length of narrow parallel portion : 60 ± 0,5
b Width of narrow parallel portion : 10 ± 0,5

R Radius, min. : 60
l_0 Distance between gauge marks : 50 ± 0,5
l_2 Initial distance between grips : 115 ± 5
d Thickness (see 5.3 and 10.1)

Figure 3 — Alternative dumb-bell specimen