INTERNATIONAL STANDARD ISO 3268

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Plastics — Glass-reinforced materials — Determination of tensile properties

Plastiques — Matières renforcées au verre textile — Détermination des caractéristiques en traction

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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 3268 was developed by Technical Committee ISO/TC 61, *Plastics*, and was circulated to the member bodies in May 1974.

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

Austria	India	Sweden
Belgium	Iran	Thailand
Brazil	Ireland	Turkey
Canada	Israel	United Kingdom
Chile	Italy	U.S.A.
Egypt, Arab Rep. of	Netherlands	U.S.S.R.
France	Poland	Yugoslavia
Germany	Romania	
Hungary	Spain	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Czechoslovakia
Switzerland

Printed in Switzerland

Plastics — Glass-reinforced materials — Determination of tensile properties

1 SCOPE AND FIELD OF APPLICATION[1)]

1.1 This International Standard specifies a method of determining certain tensile properties of textile-glass-reinforced plastics.

The method is applicable to both reinforced thermosetting resins and reinforced thermoplastics.

Injection-moulded test specimens made from reinforced thermoplastics are subject to fibre orientation, and may give values that are untypically high; however, they may be used if other methods of specimen preparation are impracticable.

1.2 The method specifies the determination of the following tensile properties :

– the initial tangent modulus of elasticity and the tensile secant modulus of elasticity;

NOTE — When it is not possible to determine the initial tangent modulus of elasticity, the tensile secant modulus of elasticity at 0,1 % strain is determined.

– the maximum tensile stress;

NOTE — If there is a clean break, the maximum tensile stress is the tensile stress at break; in other cases, it is the tensile stress corresponding to the maximum force.

– the percentage elongation at maximum force and the percentage elongation at break, as applicable.

NOTE — The force/elongation curves at different temperatures, degrees of humidity and rates of strain yield useful information concerning the behaviour of the materials.

1.3 It is only possible to obtain comparable values between different materials if identical test specimens are used. These should also be tested under well-defined conditions of pre-treatment, temperature, humidity and rate of strain.

1.4 Finally, it is the aim of this method to obtain tensile results that can be used for either

– routine quality control, or

– preparation of specifications for materials.

2 REFERENCES

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

ISO 1268, *Plastics — Preparation of glass fibre reinforced, resin bonded, low-pressure laminated plates or panels for test purposes.*

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

3 DEFINITIONS

3.1 tensile stress : The tensile force per unit area of original cross-section within the narrow parallel portion, carried by the test specimen at any moment.

3.2 percentage elongation : The increase in the distance between reference marks on the narrow parallel portion of the test specimen, due to a tensile force, and expressed as a percentage of the initial distance between the reference marks.

3.3 elastic modulus : The ratio of stress to corresponding strain within the range of the greatest stress that the material is capable of sustaining without any deviation of proportionality of stress to strain, i.e. the slope of the force/strain curve obtained in the tensile test. In the portion of the curve beyond the limit of proportionality, or if the limit does not exist, it is possible to determine the following moduli :

3.3.1 initial tangent modulus : The slope of the tangent of the force/strain curve at its origin.

NOTE — With some testing machines, the curves show local divergences at the origin, which make it impossible to draw the tangent. If this occurs, it is necessary to adjust the position of the origin on the elongation axis (see figure 1).

3.3.2 secant modulus at *x* % strain : The slope of the straight line passing through the origin (corrected, if necessary, as described in 3.3.1) of the force/strain curve and the point on the curve corresponding to an apparent strain of *x* %.

1) A new document for the testing of roving laminates (unidirectional) is under study and when completed will be integrated into this International Standard.

4 APPARATUS

4.1 Testing machine, having a constant rate of traverse and comprising the following items :

a) **Stationary or substantially stationary member,** with a suitable grip, and a **movable member** with a second grip.

The grips shall be made so as to allow, at any moment, alignment of the axis of the test specimen along the direction of the applied force. This can be achieved, for example, by using centring pins in the grips. It is suggested that self-tightening grips be used, so as to limit as completely as possible any slipping of the test specimen in the grips.

b) **Drive mechanism,** giving the movable member a uniform rate of traverse under no-load conditions, the speed being as indicated in clause 7.

c) **Force-indicating mechanism (dynamometer),** showing the force applied to the test specimen held in the grips. This mechanism shall be essentially without inertia at the speed of testing and shall indicate the force with an accuracy of within 1 % of the indicated value.

The fixed and movable members, the grips and the drive mechanism shall be constructed of such materials and be of such dimensions that the total elastic longitudinal strain of these devices is not greater than 1 % of the longitudinal strain shown simultaneously in the gauge length of the test specimen; these requirements shall be satisfied for any force less than or equal to the rated capacity of the testing machine.

4.2 Extensometer, permitting the determination, at any time during the test, of the distance between two fixed points (or reference marks) located within the central parallel portion of the test specimen.

Other techniques, in particular the measurement of strain by the displacement of the grips, are not allowed.

It is highly desirable that the extensometer used should allow a force/extension curve to be drawn.

NOTES

1 Some optical devices can be used which make it possible to follow the separation of the two reference marks.

Other extensometers (mechanical or volumetric) may be used provided that they can measure the elongation with an accuracy of at least 1 %.

2 The extensometer shall not damage the test specimens, in particular by causing breaks where it is attached.

The initial distance between the two fixed points, which is called the "gauge length", shall be known with an accuracy of 1 % or better. The elongation shall be recorded automatically as a function of the force or of the elapsed time from the beginning of the test. In this latter case, the force as a function of elapsed time shall also be recorded.

The extensometer shall be essentially without inertia at the speed of testing. It shall be accurate to 1 % or better of the indicated elongation.

The recommended gauge length is 50 mm for test specimens of type I and 100 mm for the other types. However, a shorter distance may be used, provided that the above tolerances are taken into account.

4.3 Micrometer, suitable for measuring the dimensions of the test specimen to within ± 0,01 mm.

5 TEST SPECIMENS

5.1 Types and choice of test specimen

Three types of test specimen may be used, as illustrated in figure 2. Type I is for testing glass-reinforced thermoplastics; type II (rectangular, without end pieces) and type III (rectangular, with parallelepipedic end pieces) are for testing glass-reinforced thermosets.

Type I specimens may also be used for glass-reinforced thermosets if they break within the gauge length.

The preferred width of test specimens of types II and III is 25 mm; widths of 50 mm or greater shall be used if the tensile strength is low due to the reinforcement used.

The thickness of the test specimen shall be between 2 and 10 mm.

To decide between using test specimens of type II and III, first carry out tests with a specimen of type II and if the test is not possible or not satisfactory [slipping or breaking in the grips, etc. (see 5.3)], use specimens of type III.

5.2 Preparation

5.2.1 *General*

If a comparison is to be made between different reinforced thermosets, cut the test specimens out of flat sheets prepared according to ISO 1268.

If test specimens are to be cut from finished parts (for example, for quality control during manufacture or on delivery), they should preferably be taken from flat areas or areas of minimum curvature. Furthermore, every effort shall be made to use test specimens without surface machining specifically intended to reduce their thickness. If the surfaces of the specimens have been machined to reduce their thickness, the results obtained will not be comparable with those obtained on test specimens without machined surfaces.

5.2.2 *Preparation and application of end pieces (for type III test specimens)*

A recommended method is as follows : cut out, from the material under test, a sheet having the length of the intended test specimens, and of a width suitable for the number of test specimens required. To form the end pieces, cut parallelepipedic strips, preferably from a material having a modulus of elasticity smaller than that of the material under test, of a width such that during testing, the distance between the grips will be at least 20 mm greater than the distance between the end pieces.

NOTE — For making the end pieces, it is possible to use strips of a thickness one to three times that of the material to be tested.

Attach the strips, as shown in figure 3, as follows :

a) Rub all surfaces to which adhesive will be applied, with fine abrasive paper.

b) Carefully clean these surfaces with a suitable solvent.

c) For bonding, use a cold-hardening adhesive (for example an epoxy adhesive), strictly following the manufacturer's instructions.

d) Keep the assembled parts under pressure for a sufficient time.

It is desirable that the adhesive used for bonding be of a *flexible nature with an elongation at break* greater than that of the material under test.

The strips shall be perfectly superposed at each end, parallel with each other and normal to the length direction of the test specimens.

The sheets together with the strips constituting the end pieces are the test blanks ready for cutting into test specimens.

5.2.3 *Machining of test specimens*

5.2.3.1 PRECAUTIONS

In all cases, take the following precautions :

a) Avoid working under conditions that would create too great a heat build-up in the test specimen; it is recommended that a coolant be used. If a liquid coolant is used, dry the test specimens immediately after machining.

b) Check that the sides of the test specimen are free from defects.

5.2.3.2 TYPE I TEST SPECIMENS

Test specimens of reinforced thermoplastics are usually subject to fibre orientation if injection moulded. It is, therefore, advisable in most cases to machine the specimens from compression-moulded rectangular sheets by means of a small grinding wheel or router made of a suitable material and following a template.

5.2.3.3 RECTANGULAR TEST SPECIMENS (TYPES II AND III)

These can be cut by means of a diamond or carborundum saw.

5.3 Number of test specimens

Glass-reinforced plastics are usually anisotropic. It is, therefore, often of interest to cut test specimens according to at least the two main directions of anisotropy, or according to directions previously specified (for example lengthwise or crosswise to the sheet).

For each direction and property considered (modulus of elasticity, tensile strength, etc.), at least five results are necessary.

Discard and replace any test specimens which have

— slipped in the grips;

— broken in the grips or at a distance less than 10 mm from the grips;

NOTE — However, if the majority of test specimens break in this manner, the results should be evaluated statistically to determine whether or not they represent a homogeneous population.

— undergone testing under faulty operating conditions, or have given manifestly inconsistent results for evident reasons.

The number of measurements may even be more than five if a greater precision of the mean value is required. It is possible to evaluate this by means of the confidence interval (95 % probability) (see ISO 2602).

6 PRECONDITIONING

The test specimens shall be conditioned as indicated in the particular specification of each reinforced plastic tested. If no test specification exists, they shall be conditioned for temperature and humidity for at least 16 h in accordance with ISO 291.

7 TESTING SPEEDS

7.1 The testing speed is the rate of separation of the test specimen grips when the machine is running empty.

7.2 The speed shall be chosen to give a rate of increase in strain of about 1 to 2 % per minute for qualification tests. This results in the following test speeds.

7.2.1 *For type I test specimens*

a) 2 mm/min

— for qualification tests;

— when measuring elongations;

— when determining moduli of elasticity in tension.

b) 10 mm/min for routine quality control.

7.2.2 *For type II and III test specimens*

a) 2 mm/min

— for qualification tests;

— when measuring elongations;

— when determining moduli of elasticity in tension.

b) 5 mm/min for routine quality control.

7.3 The indicated speeds, measured when the machine is running empty, shall be maintained to within a tolerance of ± 10 %.

8 PROCEDURE

8.1 Test atmosphere

Perform the tests in one of the standard laboratory atmospheres specified in ISO 291.

8.2 Measurement of test specimen dimensions

With the micrometer (4.3), measure the width b to the nearest 0,1 mm and the thickness h to the nearest 0,02 mm, at the mid-point of the specimen and within 5 mm of each end of the gauge length. Reject any test specimens whose width or thickness do not comply with the tolerances given in figure 2.

Calculate the arithmetic means for width and thickness, which shall be used for calculation purposes.

8.3 Operating technique

Place the test specimen in the grips, taking care to align the longitudinal axis of the test specimen with the mechanical axis of the testing machine. To obtain perfect alignment when centring pins are used in the grips, it is only necessary to tension the specimen slightly before tightening the grips. Tighten the grips evenly and firmly to avoid all slipping of the test specimen. Check and, if necessary, calibrate the extensometer (4.2). Attach the extensometer to the central portion of the test specimen.

NOTE — If tension is applied to the test specimens during tightening of the grip, it should be removed before setting up the extensometer.

8.3.1 *Determination of the elastic modulus*

Adjust the rate of traverse to 2 mm/min.

Record the elongations and corresponding forces.

8.3.2 *Determination of other characteristics*

Adjust the speed as indicated in 7.2.

Record the elongations and corresponding forces.

9 EXPRESSION OF RESULTS

9.1 Tensile stress at maximum force

Calculate the tensile stress, σ, in megapascals[1)], at maximum force from the formula

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

where

F is the maximum tensile force, in newtons;

b is the mean initial width of the test specimen, in millimetres;

h is the mean initial thickness of the test specimen, in millimetres.

Express the result to three significant figures.

9.2 Percentage elongation at maximum force

Calculate the percentage elongation, a, at maximum force from the formula

$$a = \frac{(Z_r/R) \times 100}{L_o} = \frac{100\, Z_r}{R\, L_o}$$

where

Z_r is the apparent extension at maximum force (see note), in millimetres, taken from the chart of apparent extension/force (see figure 1);

R is the magnification ratio of the extensometer;

L_o is the gauge length of the extensometer, in millimetres.

NOTE — The apparent extension at break is the direct reading in millimetres taken from the chart and uncorrected for the magnification ratio of the extensometer.

Express the result to two significant figures.

9.3 Initial tangent modulus of elasticity

Calculate the initial tangent modulus of elasticity, E_T, in megapascals, from the formula

$$E_T = \frac{L_o\, R}{A_o} \times \frac{\Delta F_1}{\Delta Z_1}$$

where

L_o is the gauge length of the extensometer, in millimetres;

R is the magnification ratio of the extensometer;

A_o is the initial cross-sectional area of the test specimen, in square millimetres;

ΔF_1 is the change in force, in newtons (see figure 1);

ΔZ_1 is the change in the apparent extension, in millimetres, taken from the chart corresponding to the change in force ΔF_1.

Express the result to three significant figures.

NOTE — It is recommended that, if the initial tangent modulus cannot be measured, the secant modulus at 0,1 % strain be determined instead; record it as the initial tangent modulus.

1) 1 MPa = 1 MN/m^2 = 1 N/mm^2

9.4 Tensile secant modulus of elasticity

Calculate the tensile secant modulus of elasticity, E_x, in megapascals, corresponding to x % strain from the formula

$$E_x = \frac{L_o R}{A_o} \times \frac{\Delta F_x}{\Delta Z_x}$$

where

L_o is the gauge length of the extensometer, in millimetres;

R is the magnification ratio of the extensometer;

A_o is the initial cross-sectional area of the test specimen, in square millimetres;

ΔF_x is the change in force, in newtons, corresponding to x % strain (see figure 1);

ΔZ_x is the change in apparent extension, in millimetres, taken from the chart, corresponding to the change in force ΔF_x.

Express the result to three significant figures.

10 TEST REPORT

The test report shall include the following particulars :

a) reference to this International Standard;

b) complete identification of the tested product, including the identification of type, origin, code number or producer, shape, main dimensions, preliminary treatments, etc.;

c) type of test specimen : mean, minimum and maximum values of the width and thickness of the parallel section;

d) method of preparation of the test specimen, and any details of the fabrication method used;

e) conditioning procedure;

f) temperature and relative humidity of the test room;

g) number of test specimens tested;

h) testing speed;

i) tensile stress at maximum force : mean value;

j) percentage elongation at maximum force and, if applicable, at break : mean value(s);

k) initial tangent modulus of elasticity and, if required, tensile secant modulus of elasticity at x % strain : mean value(s);

l) standard deviation of results of individual tests, and 95 % confidence interval of mean value;

m) the direction of the major axes of the test specimens in relation to the direction of some feature of the material from which they were cut;

n) if any test specimens have been rejected and replaced, and, if so, the reasons;

o) if averages were taken in two principal directions of test, and, if so, the values.

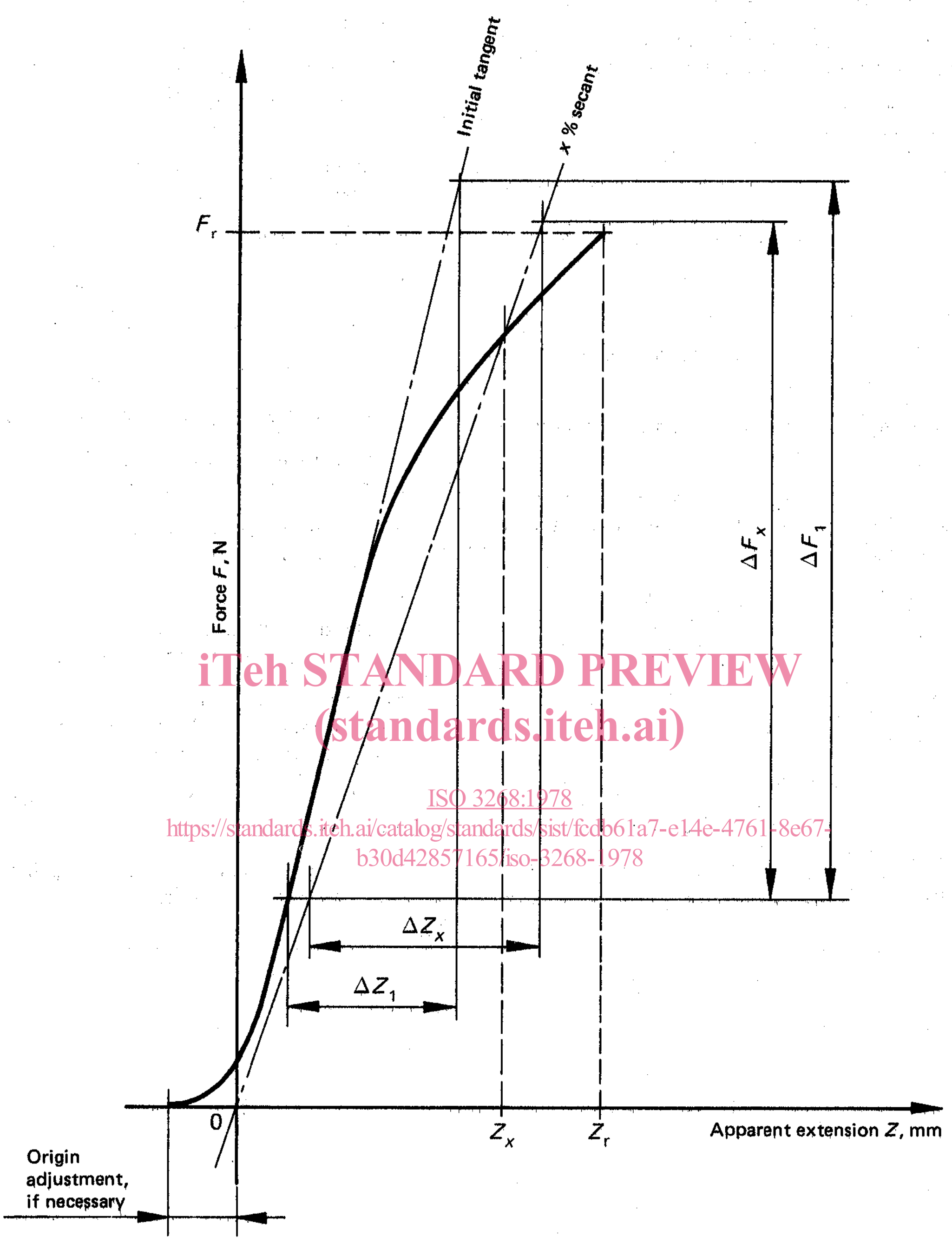
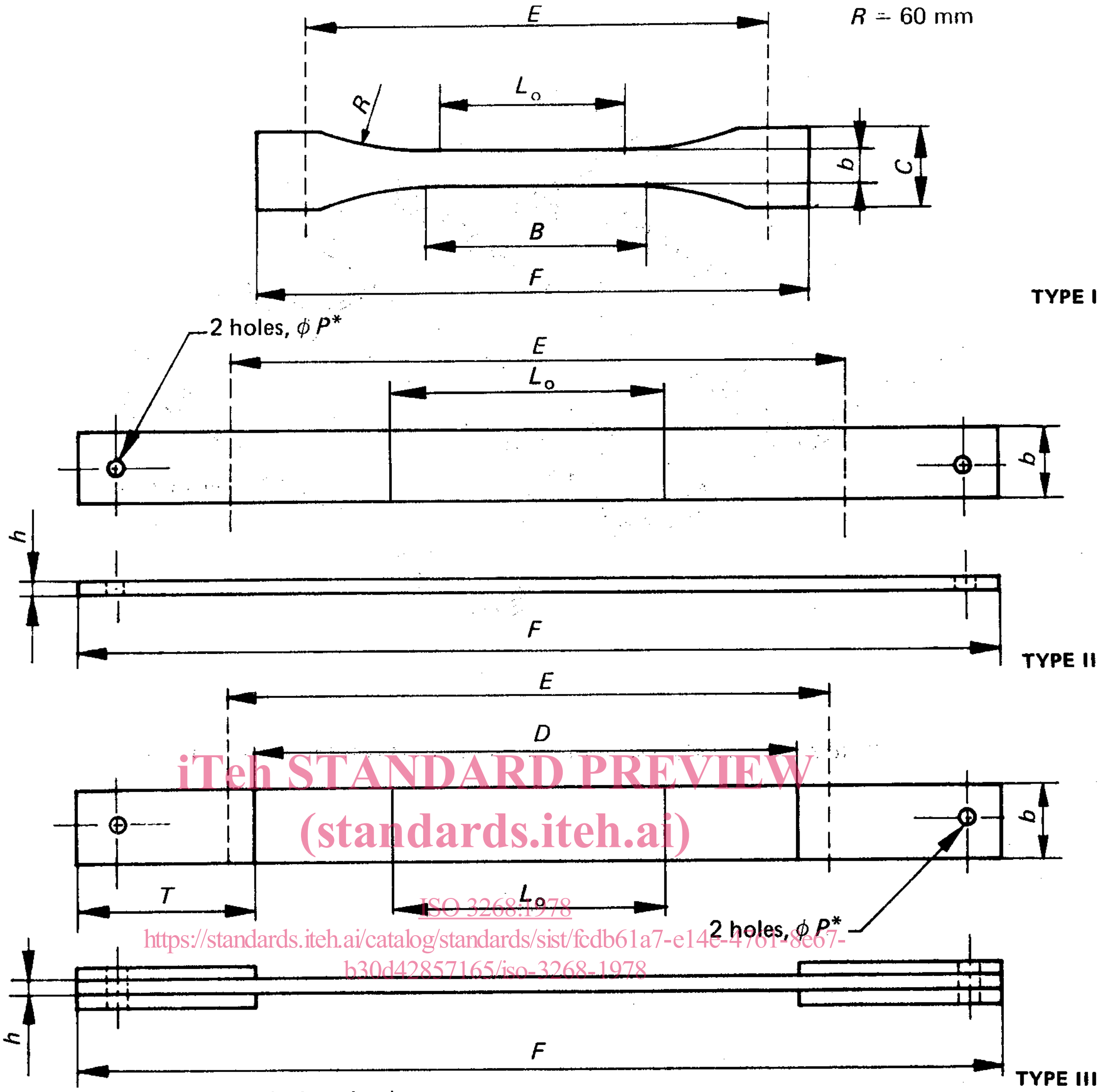


FIGURE 1 — **Chart of apparent extension (*Z*) versus force (*F*)**



* Piercing of centring holes is optional

Dimensions in millimetres

	Dimension	Type I	Type II	Type III
F	Overall length, minimum	150	250	250
C	Width of ends	20 ± 0,5	–	–
h	Thickness	2 to 10	2 to 10	2 to 10
B	Length of the middle parallel part	60 ± 0,5	–	–
b	Width of the middle parallel part	10 ± 0,5	25 or 50 ± 0,5	25 or 50 ± 0,5
L_o	Gauge length	50 ± 0,5	100 ± 0,5	100 ± 0,5
E	Distance between grips	115 ± 5	170 ± 5	170 ± 5
D	Distance between end pieces	–	–	150 ± 5
T	Minimum length of end pieces	–	–	50
P	Diameter of centring holes	–	$3^{+0,25}_{-0,05}$	$3^{+0,25}_{-0,05}$

FIGURE 2 — **Test specimens**