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Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of longitudinal tensile properties

Systèmes de canalisations en plastiques — Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Détermination des propriétés en traction longitudinale

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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International Standard ISO 8513 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*.

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of longitudinal tensile properties

1 Scope

This International Standard specifies three test methods for determining the longitudinal tensile properties of pipes of glass-reinforced thermosetting plastics (GRP). The properties which can be determined are:

— the longitudinal tensile strength

— the percentage ultimate elongation

— the longitudinal modulus of elasticity.

Method A uses for the test piece(s) a longitudinal strip cut from a pipe.

Method B uses a specified length of the full cross-section of the pipe.

Method C uses a notched plate cut from a pipe wall section.

Method A is applicable to pipes with a nominal size of DN 50 or greater with circumferentially wound filaments, with or without chopped glass and/or woven rovings and/or fillers, and to centrifugally cast pipes. It is applicable to those pipes with helically wound filaments with a nominal size of DN 200 or greater.

Method B is applicable to all types of GRP pipe. It is usually used for pipes with a nominal size up to and including DN 150.

Method C is primarily intended for use for helically wound pipes with a winding angle other than approximately 90°. This method may also be used for other types of pipe.

Results from one method are not necessarily equal to the results derived from any of the alternative methods. However, all methods have equal validity.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1
initial longitudinal tensile strength
$\sigma_{LA}*$, $\sigma_{LB}*$, $\sigma_{LC}*$
maximum tensile force in the longitudinal direction per unit mean circumference (see 2.6) at failure (the subscripts A, B and C denote the method of test used)

NOTE It is expressed in newtons per millimetre of circumference (N/mm).

2.2
ultimate longitudinal tensile stress
σ_L
maximum longitudinal tensile force per unit cross-sectional area at failure

NOTE It is expressed in newtons per square millimetre (N/mm).

2.3
ultimate elongation
ε_L
elongation coincident with the ultimate longitudinal tensile stress (see 2.2)

NOTE It is expressed as a percentage of an initial gauge length or free length of a test piece.

2.4
longitudinal modulus of elasticity
E_L
longitudinal tensile force per unit cross-sectional area divided by the strain

NOTE It is expressed in newtons per square millimetre (N/mm^2).

2.5
mean diameter
d_m
diameter of the circle corresponding with the middle of the pipe wall cross-section

NOTE 1 It is given by any of the following:

a) the average of the external diameter of the pipe minus the average of the wall thickness;

b) the external circumference of the pipe divided by $\pi (\pi \approx 3{,}141\ 6)$ minus the average of the wall thickness;

c) the average of the internal diameter of the pipe plus the average of the wall thickness.

NOTE 2 It is expressed in millimetres.

2.6
mean circumference
circumference corresponding to the mean diameter (see 2.5) multiplied by $\pi (\pi \approx 3{,}141\ 6)$

NOTE It is expressed in millimetres.

3 Principle

Test pieces comprising either strips cut longitudinally from a pipe wall segment (method A), a specified length of pipe (method B) or a notched plate cut from a pipe wall section (method C) are subjected to extension in the longitudinal direction at a constant speed such that fracture occurs within a specified time.

The tensile properties are determined using the initial dimensions of the test piece, the tensile force and the elongation.

NOTE It is assumed that the following test parameters are set by the standard making reference to this International Standard:

a) the methods to be used, i.e. method A, method B or method C;

b) the number of test pieces (see 5.5);

c) if applicable, the requirements for conditioning, e.g. temperature, humidity, time and associated tolerances (see clause 6);

d) the test temperature and its tolerance (see clause 7);

e) the properties to be measured (see clause 8).

4 Apparatus

4.1 Tensile-testing machine, of the constant rate of cross-head movement type, incorporating the following features:

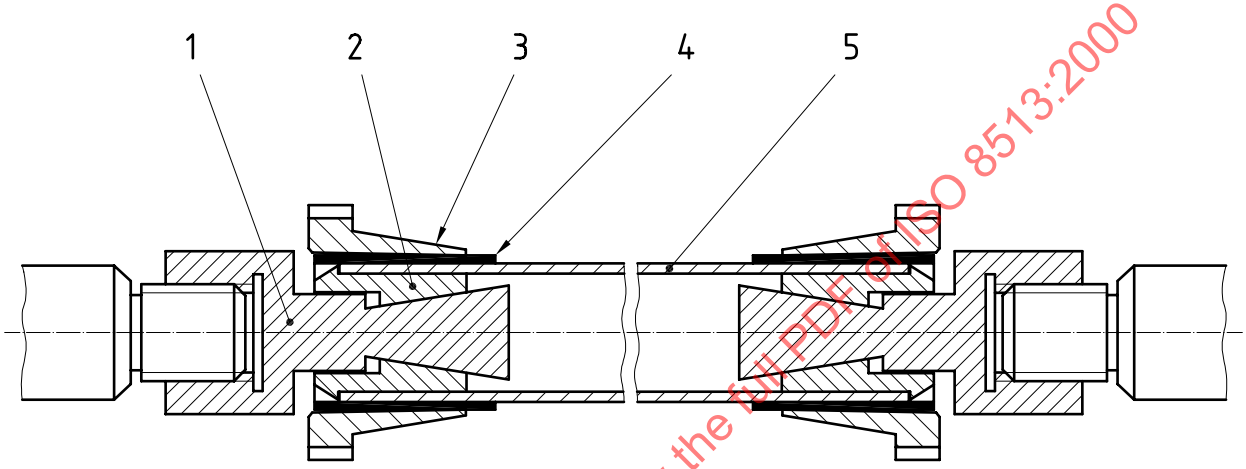
a) a fixed part, fitted with a grip to hold one end of the test piece without permitting any longitudinal movement thereof, and a moveable part, incorporating a grip to hold the other end of the test piece during extension (the

fixed and moving parts and their associated grips (see 4.2) shall enable the test piece to be aligned when a force is applied so that its longitudinal axis coincides with the direction of this force);

b) a drive mechanism, capable of imparting a constant speed of 1 mm/min to the moving part;

c) a force indicator, capable of measuring the force applied to a test piece which is held in the grips (the mechanism shall be free from significant inertia lag at the necessary speed of testing and shall indicate or record force, or consequent stress, with an accuracy of within ± 1 % of the value to be measured).

4.2 Grips, for holding the test piece. Each of the two the grips shall be capable of holding one end of the test piece without slip or crushing to an extent that will affect the results obtained. Grips which tighten automatically may be suitable. Typical grips for a pipe section test piece (see 5.3) are shown in Figure 1.



Key

1	Mandrel
2	Segmented grips
3	Sleeve
4	Reinforcing band
5	Test piece

Figure 1 — Typical grips for a pipe section test piece (method B)

4.3 Dimension measurement devices, capable of measuring the necessary dimensions of the test piece (e.g. length, width, wall thickness) to an accuracy of half the accuracy required in clause 8 for measurements, e.g. a measuring accuracy ± 0,1 mm requires a device accuracy of ± 0,05 mm.

4.4 Extension indicator, if required, capable of measuring the distance between two fixed points located within the gauge length of the test piece so that the elongation in the gauge section can be determined. The device shall be free of any significant inertia lag at the relevant speed of testing (see 8.4) and shall be accurate to within ± 1 % of the indicated value.

If strain gauges are used, these shall be mounted on both sides of the test piece, on the centreline, and the average value shall be used for the calculation of the modulus and the percentage elongation.

NOTE 1 An extension indicator is only necessary if the referring standard specifies that the elongation and/or any modulus of elasticity of the test piece is to be determined.

NOTE 2 It is desirable, but not essential, that this instrument automatically records this distance (or any change in it) as a function of the load on the test piece or of the elapsed time from the start of the test, or both. If only the latter is obtained, load/time data should be recorded as well.

5 Test pieces

5.1 General

The test piece shall be a strip or dumb-bell conforming to 5.2, or a pipe section conforming to 5.3, or a plate conforming to 5.4.

The test piece shall be obtained in such a way that it is not damaged.

5.2 Strip test piece (method A)

5.2.1 Shape

Each test piece shall be a strip cut in the longitudinal direction of the pipe and either shaped to the dimensions of the applicable dumb-bell as shown in Figure 2 or a parallel-sided (rectangular plan) test piece as shown in Figure 3.

NOTE The test pieces may be cut from a ring previously used for the determination of the initial specific ring stiffness.

5.2.2 Dimensions

5.2.2.1 Length

The length, l, of the test piece shall be (300 ± 15) mm (see Figure 2 and Figure 3).

5.2.2.2 Shaped strip

The gauge length, l_G, of the test piece shall be as follows (see Figure 2):

$$100 \text{ mm} \leqslant l_G \leqslant 150 \text{ mm}$$

The radius, R, shall be machined to conform to the following limits (see Figure 2):

$$50 \text{ mm} \leqslant R \leqslant 70 \text{ mm}$$

The width, b_G, of the test piece within the gauge length, shall conform to the following requirements, as applicable (see Figure 2 and 5.2.1):

$b_G = (10 \pm 1)$ mm for DN $\leqslant$ 150;

$b_G = (25 \pm 1)$ mm for DN $>$ 150.

The total width, b, of the test piece shall conform to the following requirements (see Figure 2):

$b = (18 \pm 2)$ mm for DN $\leqslant$ 150;

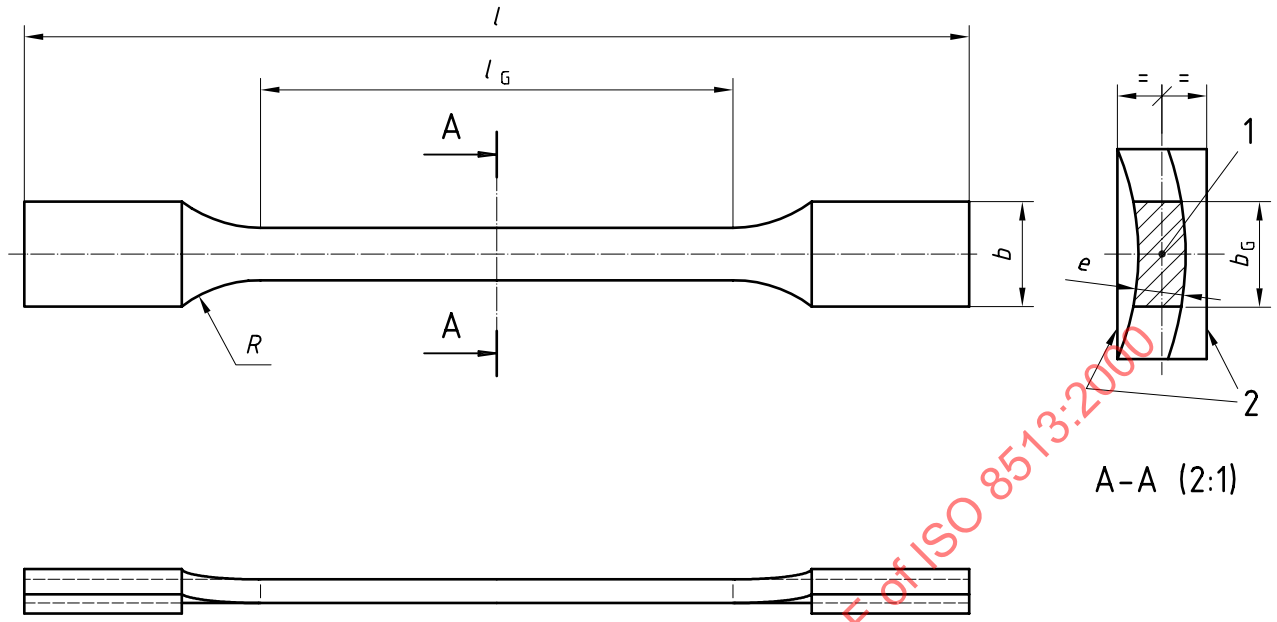
$b = (40 \pm 2)$ mm for DN $>$ 150;

5.2.2.3 Parallel-sided strip

The width, b_G, of the test piece shall be as follows (see Figure 3):

$b_G = (10 \pm 1)$ mm for DN $\leqslant$ 150;

$b_G = (25 \pm 1)$ mm for DN $>$ 150.



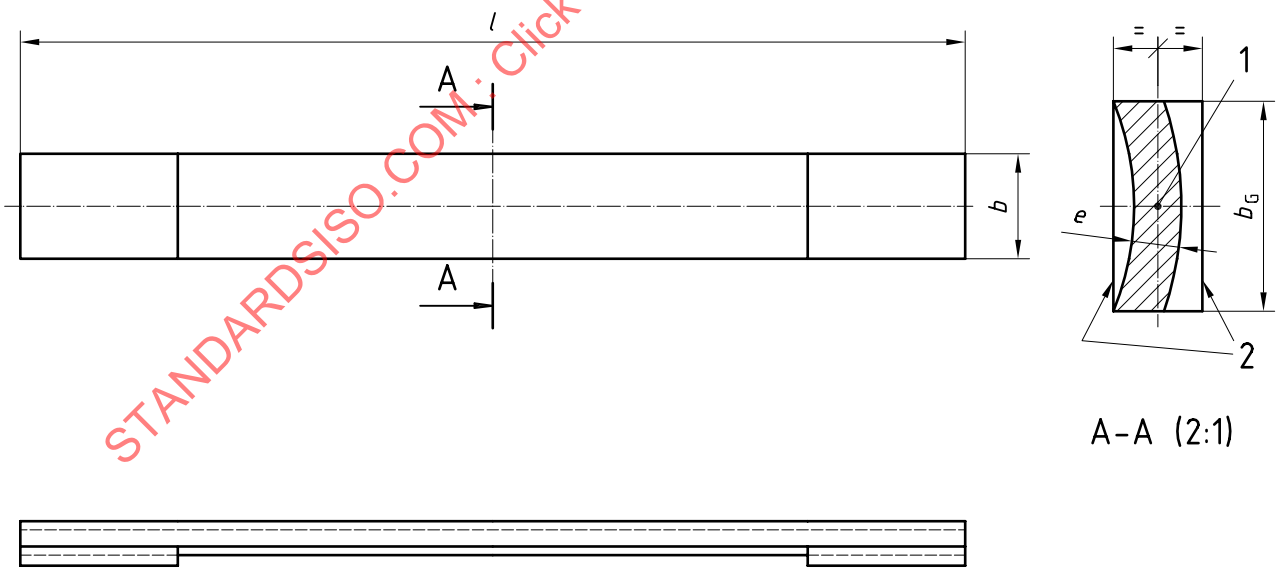
Key

1 Centroid of gauge length cross-section

2 Ends built up with plain or reinforced thermoset resin and trimmed flat and parallel, if required

e Wall thickness

Figure 2 — Shaped test piece dimensions (method A)



Key

1 Centroid of gauge length cross-section

2 Ends built up with plain or reinforced thermoset resin and trimmed flat and parallel, if required

e Wall thickness

Figure 3 — Parallel-sided strip test piece dimensions (method A)

5.2.3 Use of built-up ends

Unless grips (see 4.2) with close-fitting curved jaws are to be used, and if the manufacturer elects to utilize built-up ends, build up the thickness of the test piece ends over the grip length with a suitable thermosetting resin with or without reinforcement.

When cured, machine the built-up ends flat and parallel, and ensure that the centroid of the gauge length cross-section (see Figures 2 and 3) will lie on the loading centreline of the testing machine when gripped.

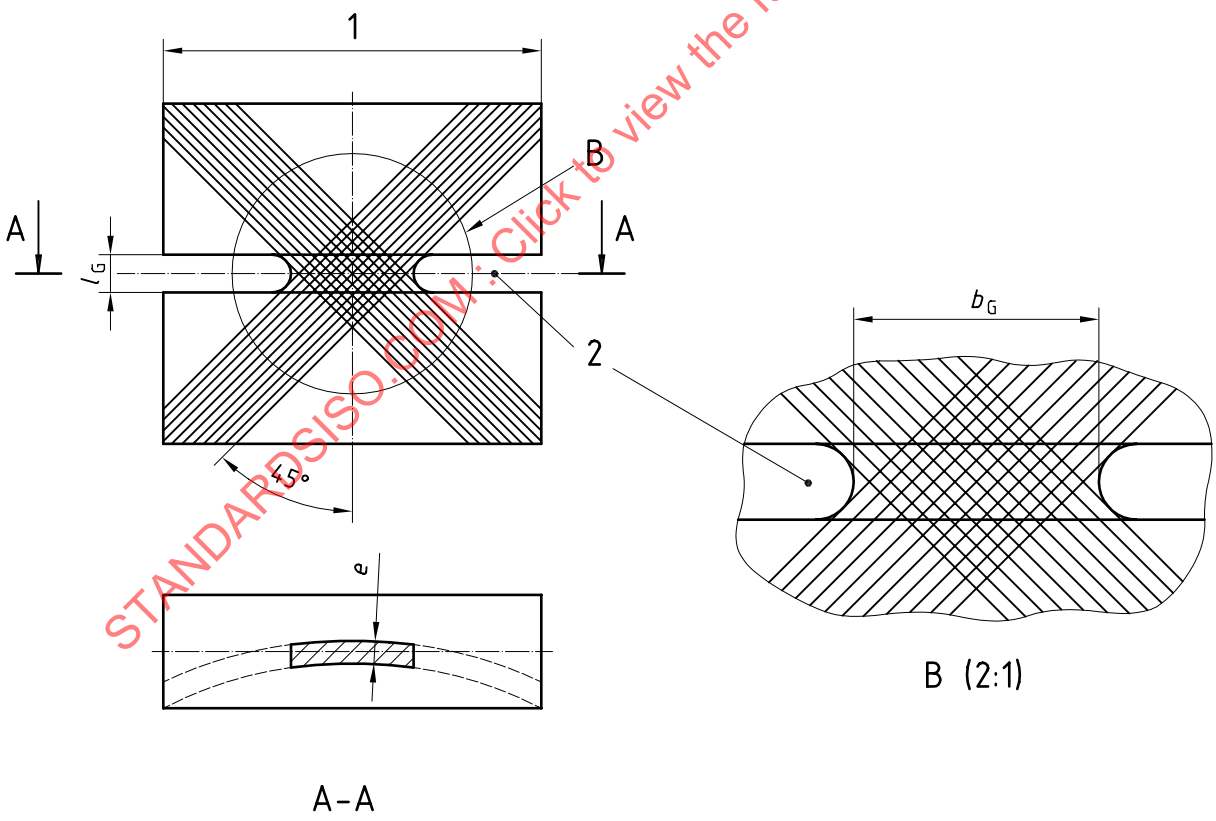
5.3 Pipe section test pieces (method B)

Each test piece (see Figure 1) shall be a full section of pipe with a minimum length of 450 mm.

5.4 Plate test pieces (method C)

The test piece (see Figure 4) shall be square and cut from the pipe so that two of the sides are parallel to and the other two sides are at right angles to the longitudinal axis of the pipe.

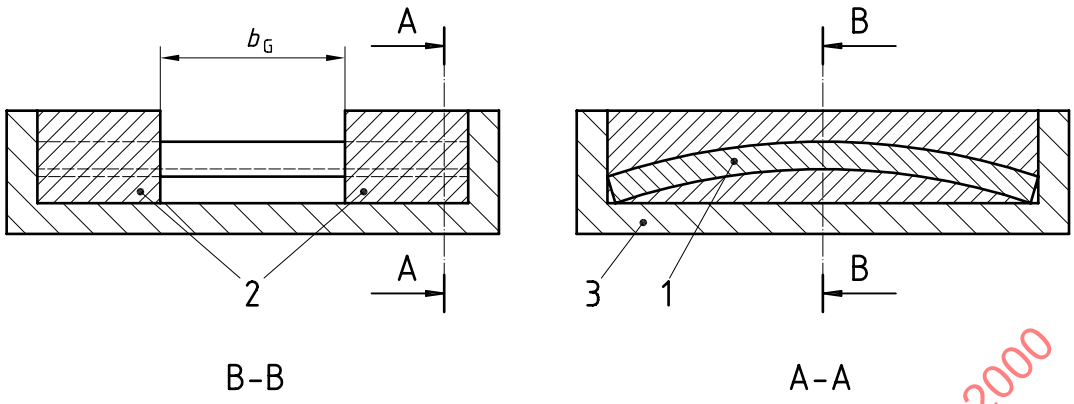
Two of the test piece sides shall be built up with thermosetting resin as described in 5.2.3 (see Figures 4 and 5).



Key

1	Periphery of pipe
2	Non-built-up section
e	Wall thickness

Figure 4 — Plate test piece (method C)



Key

1	Test piece
2	Thermosetting resin
3	Mould

Figure 5 — Application of resin to sides of plate test piece

Any flash shall be removed and the test piece shall be machined to the following dimensions (see Figure 4):

— distance between the grips, l_g:

$$l_g \geqslant 4e$$

— radius within the neck of the test piece, r:

$$0{,}2e \leqslant r \leqslant e$$

— width, b_G, of the neck:

$$4e \leqslant b_G \leqslant 5e$$

5.5 Number

The number of test pieces shall be as specified in the referring standard.

6 Conditioning

Unless otherwise specified in the referring standard, store the test pieces at the test temperature (see clause 7) for at least 0,5 h prior to testing.

7 Test temperature

Conduct the applicable procedure given in clause 8 at the temperature specified in the referring standard.

8 Procedure (methods A, B and C)

8.1 For a strip test piece (method A), measure and record to the nearest 0,1 mm the widths b and b_G, as applicable, of the test piece, at the centre of the gauge length.

For a pipe test piece (method B), measure and record either the internal or the external diameter and the average wall thickness of the test piece by taking three measurements equally spaced around the circumference at both ends of the pipe section.

For a plate test piece (method C), measure the width, b_G, with an accuracy of 0,1 mm and determine the winding angle, θ, with an accuracy of $\pm 1°$. Determine by measurement and/or calculation the radius, r.

8.2 Place the test piece in the tensile-testing machine (4.1) so that the axial alignment coincides with the direction of pull and clamp the grips (4.2) uniformly and sufficiently tightly to prevent slipping of the test piece.

8.3 Except for method C, if determination of the elongation and/or modulus is required, attach the extension indicator(s) (4.4) to the test piece.

It should be taken into account that the relative movement of the grips is not necessarily equal to the strain of the test piece. Due to the small unavoidable slipping in the grips and tolerances in the test machine, the movement between the grips is different to the strain in the test piece. Therefore the relative movement shall not be used for the determination of the modulus.

8.4 Load the test piece by separating the grips at a constant speed, in accordance with 4.1. Except for method C, if determination of modulus is required, record forces and corresponding elongations at appropriate intervals. Record the maximum force sustained by the test piece, in newtons.

8.5 Discard any test pieces which have slipped in the grips and those for which rupture has occurred outside the gauge length, and repeat the test(s) on a corresponding number of test pieces conforming to 5.2, 5.3 or 5.4.

9 Calculation

9.1 For strip test pieces (method A)

9.1.1 For each test piece, calculate the initial longitudinal tensile strength, $\sigma_{LA,i}*$, in newtons per millimetre of circumference, using the following equation:

$$\sigma_{LA,i}* = \frac{F}{b_G}$$

where

F is the maximum force, in newtons;

b_G is the gauge width of the strip test piece, in millimetres;

i is the number of the test piece.

Calculate the average initial longitudinal tensile strength, $\sigma_{LA,}*$, of the test pieces and, if applicable, the standard deviation.

9.1.2 For each test piece, calculate the percentage ultimate elongation. For all the test pieces, determine the average percentage ultimate elongation and the standard deviation, if applicable.

9.1.3 If required, calculate the longitudinal modulus of elasticity, $E_{L,i}$, of each test piece, in newtons per square millimetre, using the following equation (see Figure 6):

$$E_{L,i} = \frac{\Delta F}{b_G \times \Delta\varepsilon \times e}$$

where

ΔF is the change in force, in newtons;

$\Delta\varepsilon$ is the corresponding change in strain;