INTERNATIONAL STANDARD

ISO 8513

Second edition
2014-05-01

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the apparent initial longitudinal tensile strength

Systèmes de canalisations en plastiques — Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Méthodes d'essai pour la détermination de la force en traction longitudinale apparente

Reference number
ISO 8513:2014(E)

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Published in Switzerland

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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).

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The committee responsible for this document is ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 06, *Reinforced plastics pipes and fittings for all applications*.

This second edition cancels and replaces the first edition which has been technically revised.

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the apparent initial longitudinal tensile strength

1 Scope

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

— the longitudinal tensile strength and

— the percentage ultimate elongation.

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 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 can 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.

Annex A describes additional considerations for method B that have been found useful for the testing of thin-walled helically wound pipes and can be used to supplement the basic text.

NOTE This International test method does not address the determination of longitudinal tensile modulus. Due to the multi-layer construction of many GRP pipes, the accurate measurement of strain, necessary for modulus determination, can be very difficult. If it is desired to determine longitudinal modulus, it is recommended that ISO 527-4 and/or ISO 527-5 be consulted.

2 Terms and definitions

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

2.1
helical wound
sometimes called cross wound, refers to filament-wound pipes made with a balanced winding angle

2.2
longitudinal tensile strength
σ_{LA}^*
σ_{LB}^*
σ_{LC}^*
maximum tensile force in the longitudinal direction per unit mean circumference at failure (the subscripts A, B, and C denote the method of test used)

Note 1 to entry: It is expressed in newtons per millimetre of the circumference (N/mm).

2.3
mean circumference
circumference corresponding to the mean diameter multiplied by π (π ≈ 3,141 6)

Note 1 to entry: It is expressed in millimetres.

2.4
mean diameter
d_m
diameter of the circle corresponding with the middle of the pipe wall cross-section

Note 1 to entry: 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 π (π approximately 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 to entry: It is expressed in millimetres.

2.5
ultimate longitudinal tensile stress
$\sigma_{L,ULT}$
maximum longitudinal tensile force per unit cross-sectional area at failure

Note 1 to entry: It is expressed in newtons per square millimetre (N/mm).

2.6
ultimate elongation
ε_L
elongation coincident with the ultimate longitudinal tensile stress

Note 1 to entry: For the purposes of this International Standard, the measurement of elongation is limited to measurement of the movement of the tensile testing machine cross-heads.

Note 2 to entry: It is expressed as a percentage of an initial gauge length or free length of a test piece.

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 cross-head movement.

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);

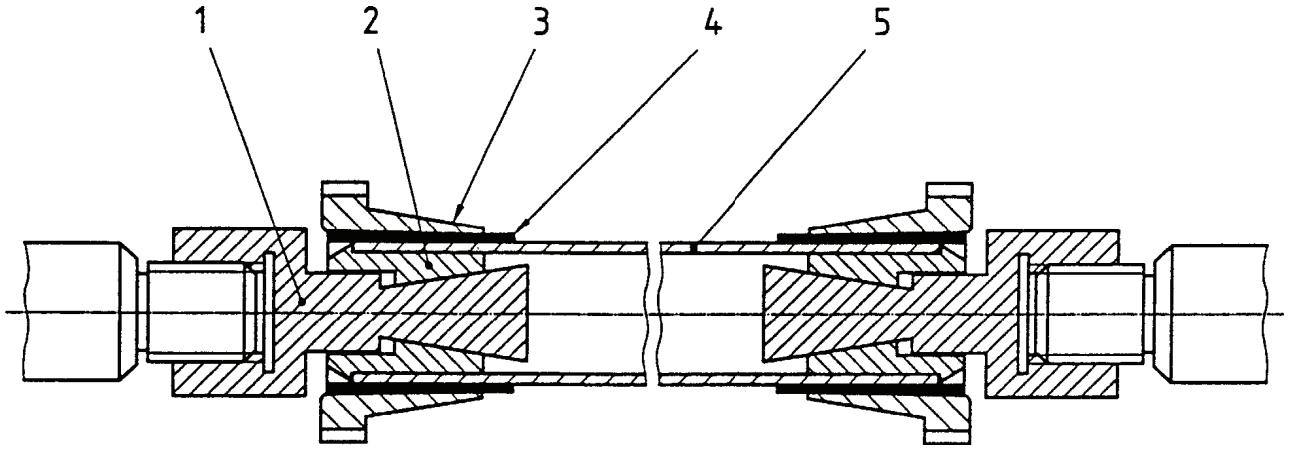
b) a drive mechanism, capable of imparting a constant speed (see 8.3) to the moving part;

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);

d) a means to measure the cross-head movement as a function of the applied load.

4.2 Grips, for holding the test piece.

Each of the two 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 might 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 of ±0,1 mm requires a device accuracy of ±0,05 mm.

5 Test pieces

5.1 General

The test piece shall be a strip or dumbbell 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.

The test piece width guidelines might, of necessity, need to be altered for thick wall pipes to smaller values to reflect the testing machine capacity. This is due to some GRP pipes being made in very high thickness to address high pressure and large diameter applications. The testing of such narrower samples will lead to a more conservative indication of strength for thick wall pipes.

For thick wall test pieces, it might also be necessary to clamp the specimen on the cut cross-section sides to allow the specimen to fit into the testing grips.

For pipes with a layered wall construction, it might also be necessary to reinforce the gripped ends to obtain a more even distribution of tensile force.

For pipes reinforced in the axial direction with tapes, fabrics, or mats of a fixed width, it might be necessary to increase the test sample length to ensure that a cross-section with the minimum number of layers of reinforcement (the apparent lowest strength area) falls within the gauge length.

NOTE The test pieces for methods A and C can be cut from a ring previously used for the determination of the initial specific ring stiffness.

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 dumbbell as shown in Figure 2 or a parallel-sided (rectangular) test piece as shown in Figure 3.

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):

$$100 \text{ mm} \leq l_G \leq 150 \text{ mm} \quad (1)$$

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

$$50 \text{ mm} \leq R \leq 70 \text{ mm} \quad (2)$$

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

$$b_G = (10 \pm 1) \text{ mm for DN} \leq 150 \quad (3)$$

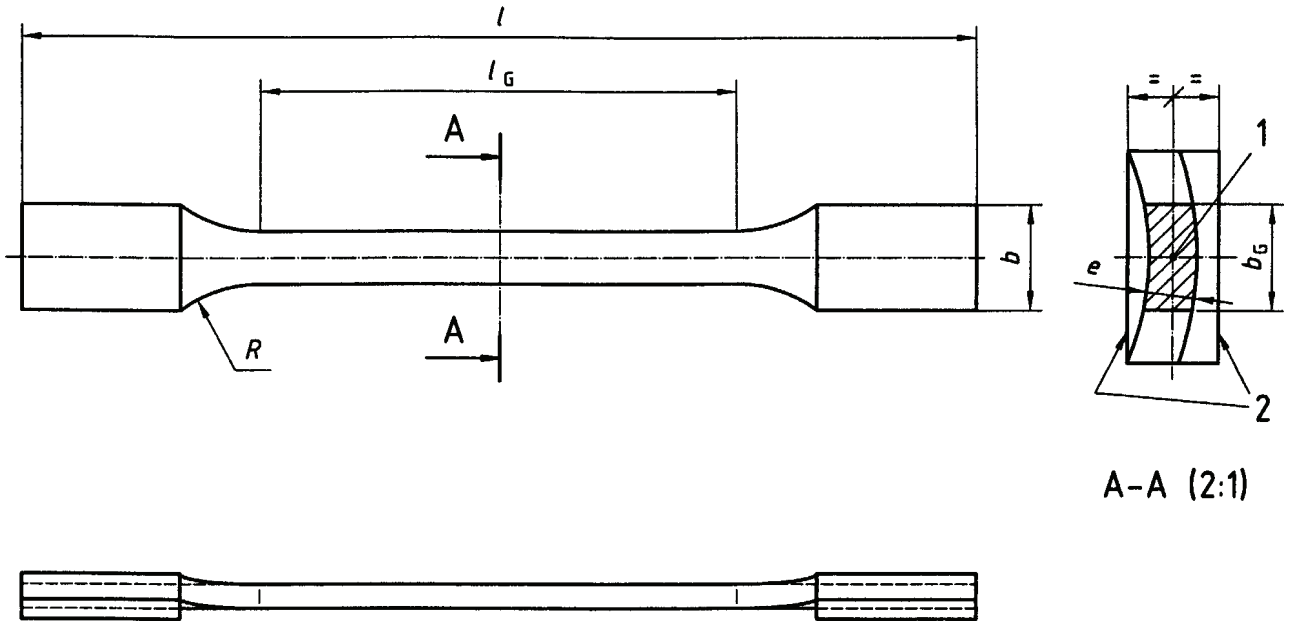
$$b_G = (25 \pm 1) \text{ mm for DN} > 150 \quad (4)$$

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

$$b = (18 \pm 2) \text{ mm for DN} \leq 150 \quad (5)$$

$$b = (40 \pm 2) \text{ mm for DN} > 150 \quad (6)$$

The above width guidelines might need to be reduced to accommodate thick wall pipes (see 5.1).



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
l test sample length
l_G gauge length
b total test sample width
b_G width of gauge length
R radius

Figure 2 — Shaped test piece dimensions (method A)

5.2.2.3 Parallel-sided strip

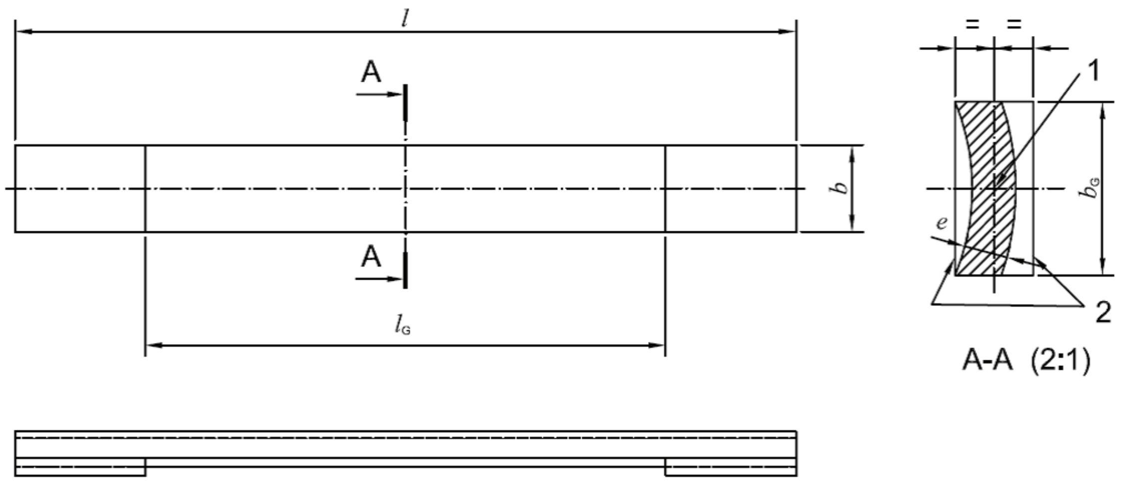
The width, b_G, of the test piece within the gauge length shall conform to the following requirements (see Figure 3). The gauge length, l_G, shall be the non-built up area between the grips.

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

$$b_G = (10 \pm 1) \text{ mm for DN} \leq 150 \quad (7)$$

$$b_G = (25 \pm 1) \text{ mm for DN} > 150 \quad (8)$$

The above width guidelines might need to be reduced to accommodate thick wall pipes (see 5.1).



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

l test sample length

l_G gauge length

b test sample width = gauge width b_G

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 the 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.

In order to avoid eccentric stress, the test piece sides that are gripped shall be built up with thermosetting resin as described in 5.2.3 (see Figure 4 and Figure 5).