
**Glass-reinforced thermosetting
plastic (GRP) pipes — Test methods
for the determination of the initial
circumferential tensile wall strength**

*Tubes en plastiques thermodurcissables renforcés de verre (PRV) —
Méthodes d'essai pour la détermination de la résistance à la traction
circonférentielle initiale de la paroi*

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document 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*.

This third edition cancels and replaces the second edition (ISO 8521:2009), which has been technically revised.

The main changes compared to the previous edition are as follows:

- For methods C and D, an allowance for using a notched specimen has been added.
- The way to grip samples for methods C and D has been clarified.
- For method D, an alternative allowed splitting of samples lengthwise has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Glass-reinforced thermosetting plastic (GRP) pipes — Test methods for the determination of the initial circumferential tensile wall strength

1 Scope

This document specifies six test methods for the determination of the initial circumferential tensile wall strength per unit of length of glass-reinforced thermosetting plastics (GRP) pipes.

NOTE Another commonly used term for “circumferential tensile strength” is “hoop tensile strength” and the two expressions can be used interchangeably.

The burst test (method A) is suitable for all types and sizes of pipes. It is considered the reference method. However, all the methods in this document have equal validity. If correlation of any of the methods B to F can be established by a comparative test programme, then that method can be considered as the reference method.

The split disc test (method B) is not always suitable for pipes with helically wound reinforcing layers.

The strip test (method C), the modified strip test (method D) and the restrained strip test (method E) are suitable for pipes with a nominal size of DN 500 and greater.

The notched plate test (method F) is primarily intended for use with helically wound pipes of nominal size greater than DN 500 with a winding angle other than approximately 90°.

Results from one method are not necessarily equal to the results derived from any of the alternative methods.

If required, the initial circumferential tensile modulus can be determined by method A.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/>

3.1

initial circumferential tensile wall strength

σ_{cA}^* , σ_{cB}^* , σ_{cC}^* , σ_{cD}^* , σ_{cE}^* , σ_{cF}^*

ultimate tensile force (3.4) per unit length in the circumferential direction

Note 1 to entry: The upper-case subscripts denote the method of test used.

Note 2 to entry: It is expressed in newtons per millimetre of circumference.

**3.2
burst pressure**

p_{ult}
internal pressure at *bursting* (3.3)

Note 1 to entry: It is expressed in bars¹⁾ or megapascals.

**3.3
bursting**

failure by rupture of the pipe wall

**3.4
ultimate tensile force**

F_{ult}
tensile force at failure

Note 1 to entry: It is expressed in newtons.

**3.5
test width**

b
width of the test piece in the notched area

Note 1 to entry: It is expressed in millimetres.

**3.6
total width**

b_{tot}
total width of the test piece

Note 1 to entry: It is expressed in millimetres.

**3.7
winding angle**

θ
angle between the direction of the continuous reinforcement and the longitudinal axis of the pipe

Note 1 to entry: It is expressed in degrees.

**3.8
helically wound**

filament wound pipes made with a balanced *winding angle* (3.7)

4 Principle

4.1 General

It is assumed that the following test parameters are set by the referring standard:

- a) for method A, the distance between end sealing devices (see 6.1);
- b) the number of test pieces (see 6.7);
- c) the requirements for conditioning (see Clause 7);
- d) the test temperature (see Clause 8).

1) 1 bar = 0,1 MPa 10^5 N/m² = 0,1 N/mm².

4.2 Method A

The initial circumferential tensile wall strength, σ_{CA}^* , is determined by an internal pressure test.

Cut lengths of pipe are subjected to an increasing internal pressure which, within a specified time, causes bursting (see 3.3). The test conditions are such that a mainly uniaxial circumferential stress is obtained.

4.3 Method B

The initial circumferential tensile wall strength, σ_{CB}^* , is determined by a split disc test.

Rings cut from the pipe are subjected to an increasing tensile force, by means of a split disc positioned within the ring, until rupture occurs within a specified time.

4.4 Methods C, D and E

The initial circumferential wall strength, σ_{CC}^* or σ_{CD}^* or σ_{CE}^* , is determined by a strip test.

Strips cut from the pipe wall in the circumferential direction, and if necessary, shaped to incorporate notches at defined locations, are subjected to an increasing tensile force until rupture occurs within a specified time.

4.5 Method F

The initial circumferential wall strength, σ_{CF}^* , is determined by a notched plate test.

Plates cut from the pipe wall are subjected to an increasing tensile force until rupture occurs within a specified time.

5 Apparatus

5.1 For method A

5.1.1 Hydrostatic pressurising system, capable, for pipes up to DN 500, of causing failure of the test piece between 1 min and 3 min after commencing the pressurization.

For some nominal sizes greater than DN 500, the duration of the test will, for practical equipment reasons, need to be increased. Where increasing the testing time results in lower burst pressures, this shall be evaluated by comparing results of different test durations.

The pressurising system shall prevent air from entering the test piece during pressurization to failure.

5.1.2 Pressure measuring device, calibrated within an accuracy of $\pm 2,0\%$.

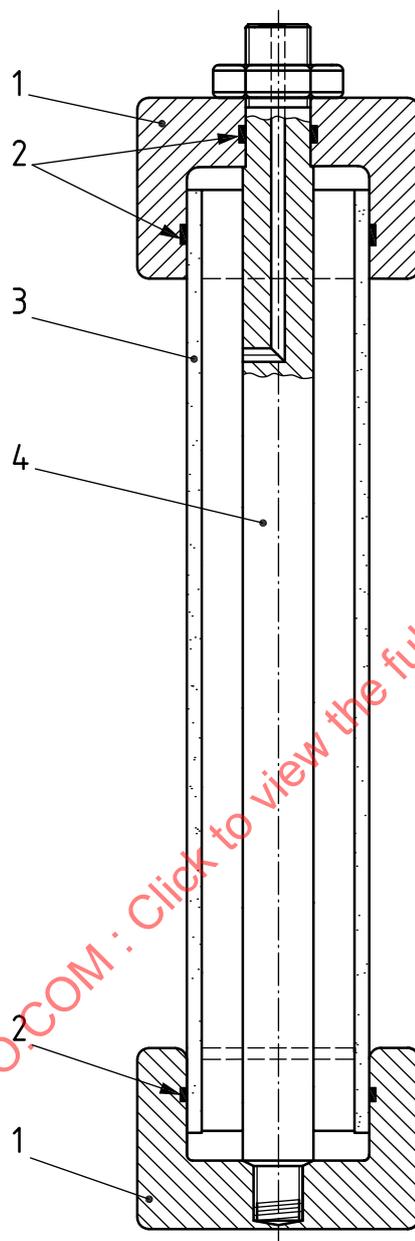
5.1.3 End sealing devices for the test pieces, capable of inducing in the test piece, during the test, a mainly uniaxial state of stress in the circumferential direction in the test piece (see [Figure 1](#)).

5.1.4 Dimension measurement devices, calibrated within an accuracy of $\pm 0,1$ mm.

5.1.5 Test piece support, if needed, to minimize deformation due to the weight of the test piece and its contents.

5.1.6 Strain measurement, if circumferential tensile modulus of the pipe wall is to be determined, strain gauges of the foil type, single element suitable for the anticipated strain level and of a length appropriate for the pipe diameter.

5.1.7 Flexible membrane, if used as a barrier system to prevent weeping, which does not reduce the stress in the pipe wall by more than 1 %. The flexible membrane may be of a different material from the pipe, e.g. elastomeric or thermoplastic sheet or a flexible coating.



Key

- | | | | |
|---|--------------------|---|---------------------------------|
| 1 | end sealing device | 3 | test piece |
| 2 | elastomeric seal | 4 | tie bar for carrying end thrust |

Figure 1 — Typical arrangement for pressure testing pipes (method A)

5.2 For method B

5.2.1 Test machine, capable of producing a progressive separation of the split disc and incorporating the following components:

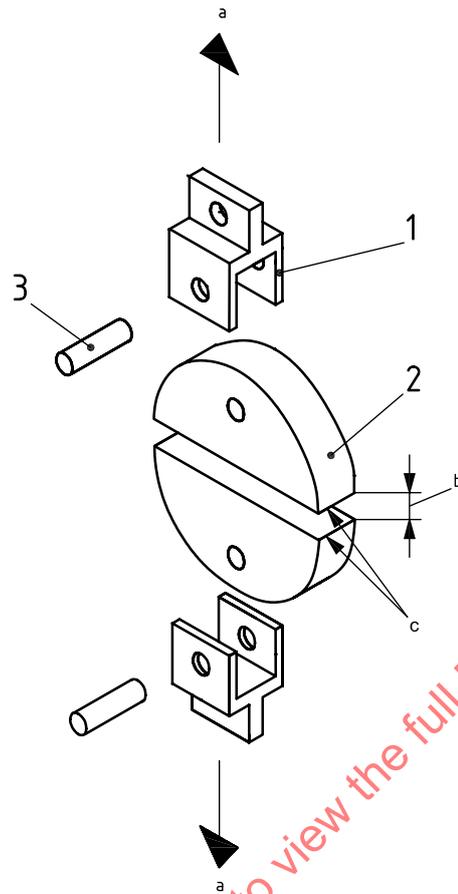
- a) a fixed or virtually fixed part;

- b) a moveable part;
- c) a drive mechanism, capable of imparting a constant speed to the moving part so that rupture can be reached between 1 min and 3 min after initial loading;
- d) a load indicator, capable of measuring the force applied. This shall be virtually free from inertia at the specified rate of testing and shall indicate the force to an accuracy of within 1 % of the measured value.

5.2.2 Rigid split discs, as shown in [Figure 2](#), capable of making even contact with the internal diameter of the test piece. The diameter of the two segments of the split disc shall be not less than 98 % of the internal diameter of the pipe with which they are intended to be used.

5.2.3 Dimension measuring devices, calibrated within an accuracy of $\pm 0,1$ mm.

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Key

- 1 toggle
- 2 saddle
- 3 shear pin

- a Direction of loading.
- b Separation.
- c Rounded edges.

Figure 2 — Typical arrangement for the split disc test (method B)

5.3 For method C

5.3.1 Test machine, with constant separating speed, incorporating the following components:

- a) a fixed, or virtually fixed, part with a grip to hold one end of a test piece;
- b) a moveable part, incorporating a second grip to hold the other end of the test piece. The grips holding the ends of the test piece shall do so as far as possible without slipping and/or crushing. Grips that tighten automatically may be used;
- c) the fixed and moving parts and their associated grips shall enable the test piece to be aligned when a force is applied, so that the axis of the test piece is coincident with that of the force;
- d) a drive mechanism capable of imparting a constant speed to the moving part, so that failure can be reached between 1 min and 3 min after initial loading;
- e) a load indicator capable of measuring the force applied. The mechanism shall be virtually free from inertia lag at the specified rate of testing and shall indicate the force to an accuracy of within 1 % of the measured value.

5.3.2 Dimension measuring device(s), capable of measuring the necessary dimensions of the test piece to an accuracy of $\pm 0,1$ mm.

5.4 For method D

5.4.1 Test machine, conforming to [5.3.1](#) (see also [Figure 6](#)).

5.4.2 Dimension measuring device(s), calibrated within an accuracy of $\pm 0,1$ mm.

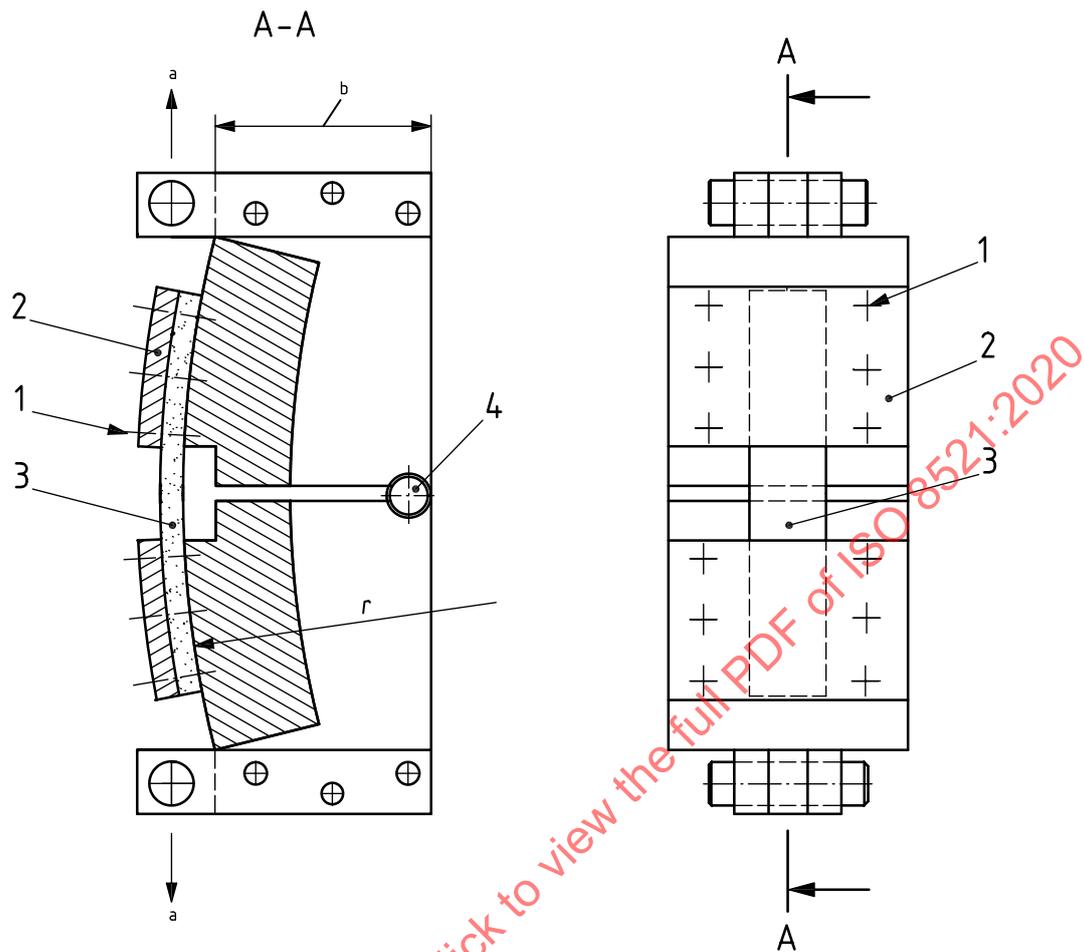
5.5 For method E

5.5.1 Test machine, conforming to [5.3.1](#) (see also [Figure 3](#)).

5.5.2 Dimension measuring device(s), capable of measuring the necessary dimensions of the test piece to an accuracy of $\pm 0,1$ mm.

5.5.3 Restraining fixture, capable of preventing the test piece from bending. The radius of curvature of the support plate shall be half the nominal size, DN, expressed in millimetres, ± 5 %. An example of such a fixture is shown in [Figure 3](#).

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Key

- 1 bolt
- 2 clamping plate
- 3 test piece
- 4 pivot

- a Direction of loading.
- b Adjustable distance.
- $r = 0,5 \cdot d_i$

Figure 3 — Typical arrangement for restrained-strip test with a split support (method E)

5.6 For method F

5.6.1 Test machine, conforming to [5.3.1](#).

5.6.2 Load indicator, capable of indicating the force applied to the test piece to an accuracy of $\pm 1\%$ of the indicated value.

5.6.3 Means of measuring the necessary dimensions of the test piece to an accuracy of $\pm 0,1$ mm and the winding angle, θ , to an accuracy of $\pm 1^\circ$.

6 Test pieces

6.1 For method A

The length of the test piece shall be as specified in the referring standard.

6.2 For method B

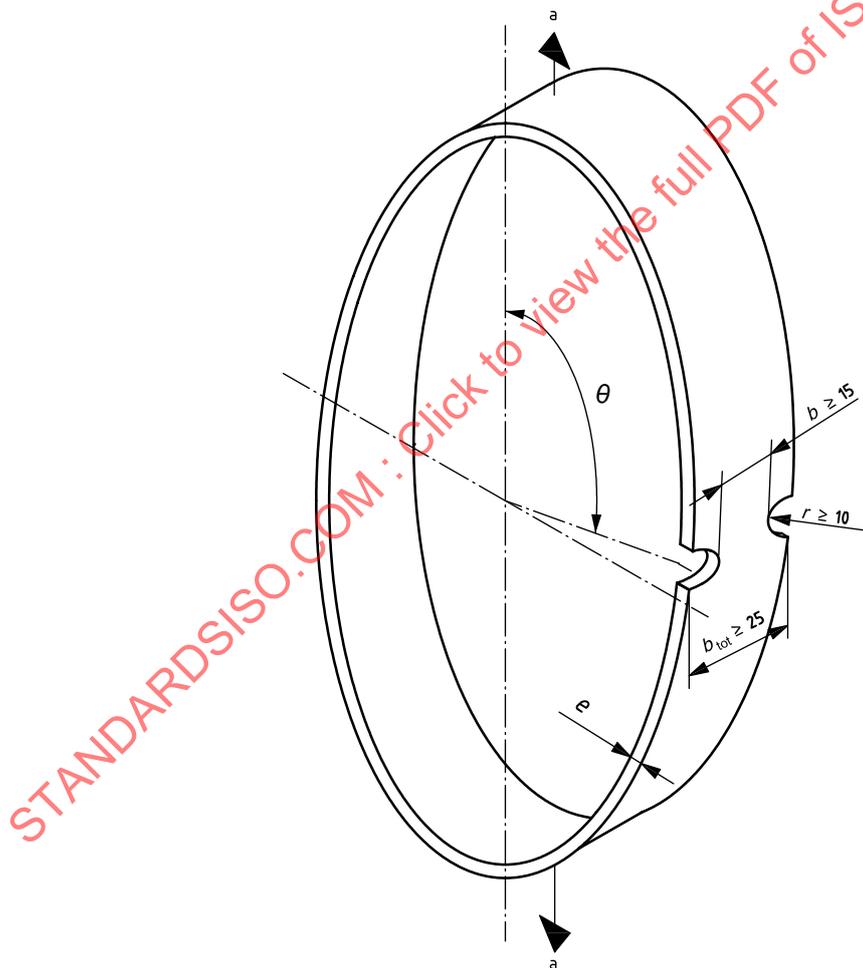
The test piece shall be a ring cut from a pipe, see [Figure 4](#).

The width of the test piece shall not exceed the width of the split disc. The width of the test section, b , shall be a minimum of 15 mm.

NOTE For larger diameter and/or higher pressure pipes, the width of the test section might, for practical equipment reasons, need to be reduced.

The ends of the ring shall be smooth and perpendicular to the longitudinal axis of the pipe.

Dimensions in millimetres



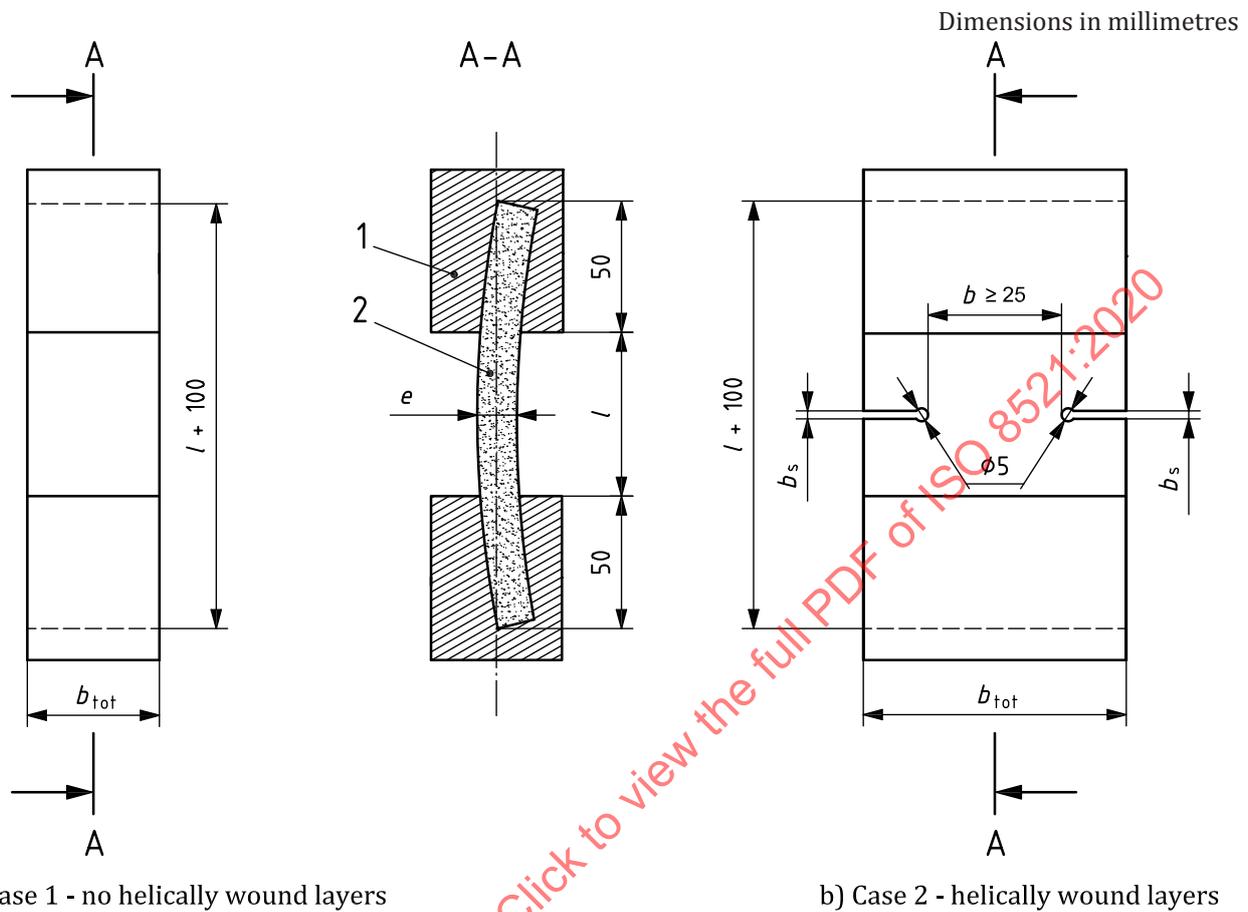
Key

e	wall thickness of test piece	b	width of test section
θ	angle equal to approximately 80°	b_{tot}	width of test piece
r	notch radius	a	Direction of loading.

Figure 4 — Test piece for split-disc test (method B)

6.3 For method C

The test pieces (see Figure 5) shall be cut out of the pipe in the circumferential direction.



Key

- | | | | |
|------------------------|---|----------|---|
| 1 | cast-resin end | <i>e</i> | wall thickness of test piece |
| 2 | test piece | <i>l</i> | length of test piece (between 4 <i>e</i> and 5 <i>e</i>) |
| <i>b_s</i> | free slot width (between 5 mm and 1 mm) | <i>b</i> | width of test section |
| <i>b_{tot}</i> | total width | | |

Figure 5 — Test piece for strip test (method C)

The test piece conforming to case 1 (see Figure 5) shall be used when helically wound reinforcing layers are not present or are present with a winding angle of $\theta > 70^\circ$. The test piece conforming to case 2 (see Figure 5) shall be used when helically wound reinforcing layers with a winding angle of $\theta \leq 70^\circ$ are present.

The ends shall be smooth and perpendicular to the longitudinal axis of the pipe.

For case 1, the total width, b_{tot} , shall be as specified in the referring standard, but at least $(25 \pm 0,5)$ mm. A test piece containing a notch conforming to the notch configurations shown in Figure 7 (case 1) may be used.

For case 2, the total width, b_{tot} , shall be as specified in the referring standard, but at least $2b$ ($b \geq 25$ mm) to prevent shear failure. Failures not occurring in the notched area shall not be considered.

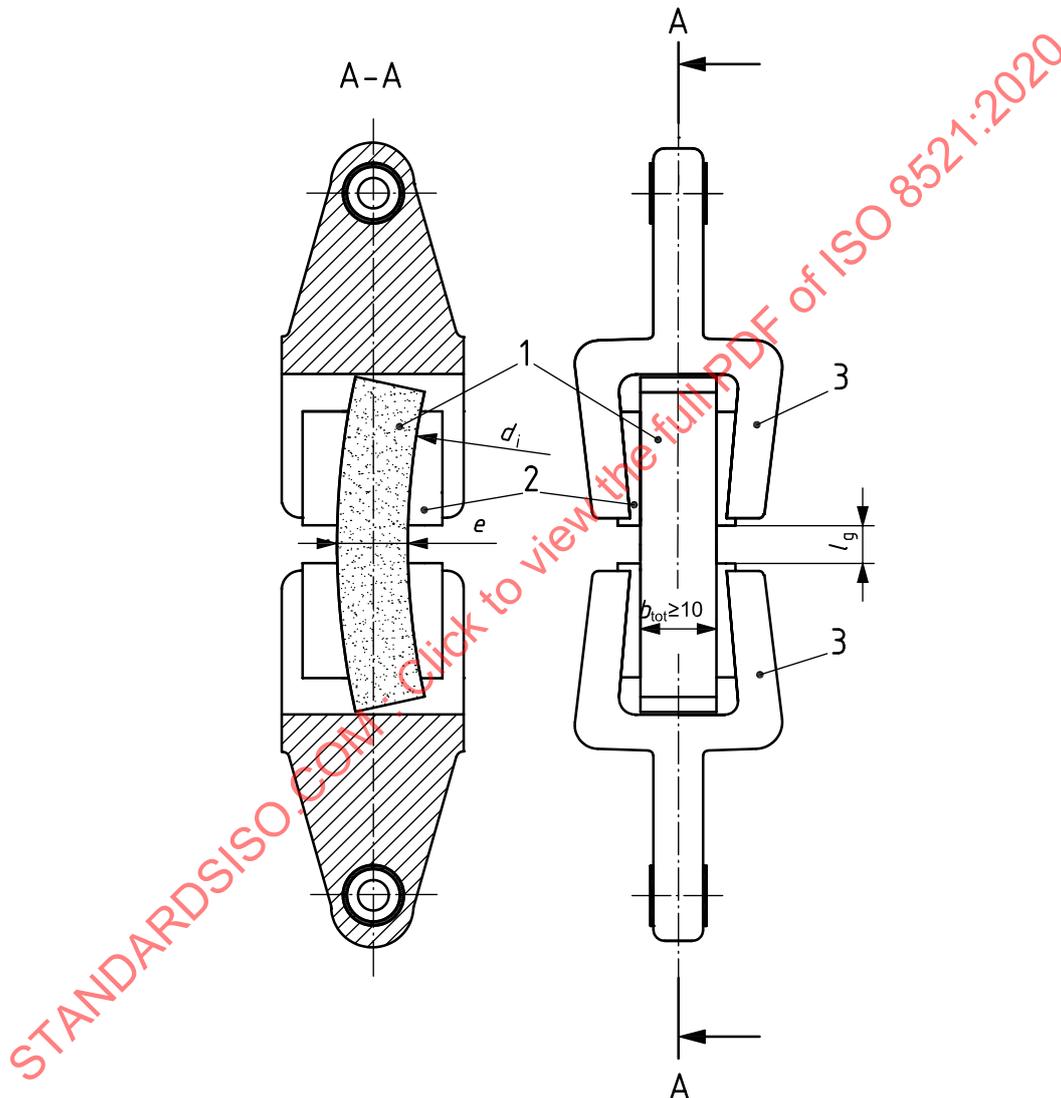
NOTE For larger diameter and/or higher pressure pipes, the width of the test piece might, for practical equipment reasons, need to be reduced.

The ends of the strip shall be encased in thermosetting resin as shown in [Figure 5](#).

6.4 For method D

When it is required only to determine conformity to a minimum strength requirement, the test piece shall be cut out of the pipe in the circumferential direction and shaped to the dimensions shown in [Figure 6](#). If, when using parallel-sided strips, the test piece fails before the minimum force is applied, the test shall be repeated using a test piece containing a notch conforming to the notch configurations shown in [Figure 7](#), case 1.

Dimensions in millimetres



Key

- | | | | |
|-----|------------------------------|-----------|--|
| 1 | test piece | l_g | distance between grips (15 ± 5) mm |
| 2 | tapered clamp | b_{tot} | width of test piece |
| 3 | grip | d_i | internal diameter |
| e | wall thickness of test piece | | |

Figure 6 — Typical test arrangement for modified strip test (method D)

The faces of the test piece in contact with the clamp shall be smooth and perpendicular to the axis of the pipe.

The width, b , shall be as specified in the referring standard but not less than 10 mm.

NOTE 1 For larger diameter and/or higher pressure pipes, the width of the test piece might, for practical equipment reasons, need to be reduced.

In order to prevent shear failure, the distance between the grips, l_g , shall be (15 ± 5) mm.

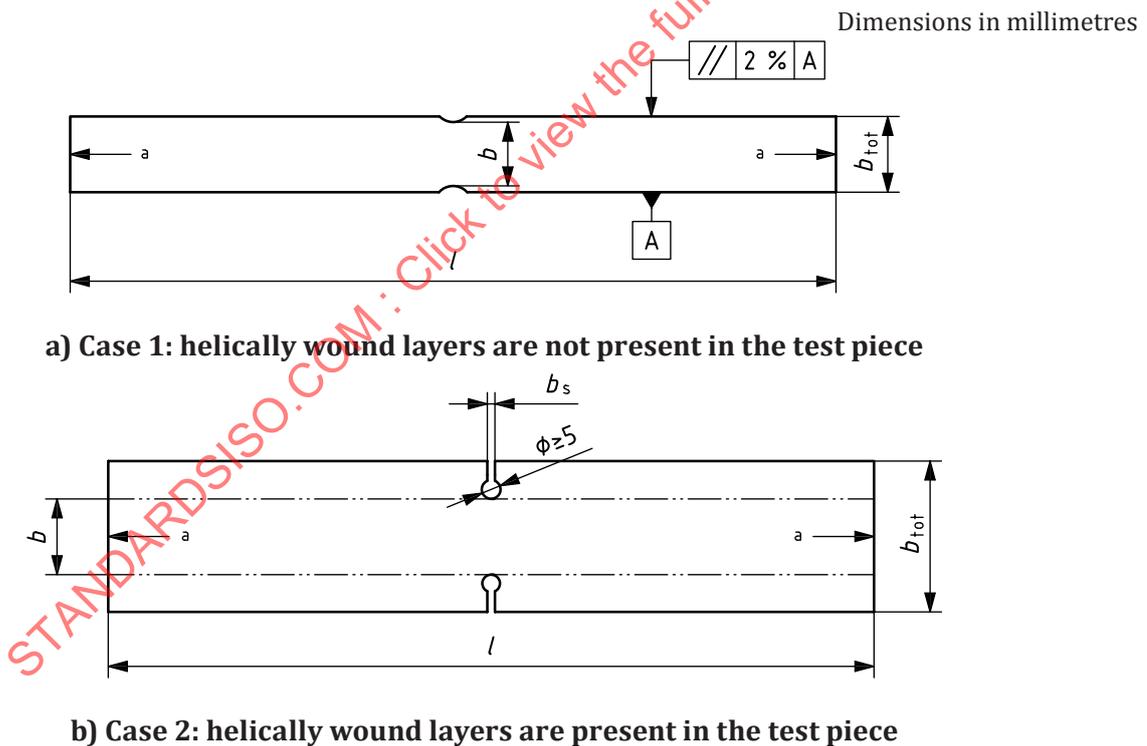
The total length of the test piece shall be adjusted to suit the grip arrangement.

NOTE 2 To prevent failure in the clamping area, it is possible to reinforce the clamped ends with suitable laminate.

If the test results from testing a sandwich wall construction show shear failure of the core of the specimen instead of tensile failure, the results are invalid. In such cases it is allowed to make a new specimen, split the sample in two through the core (not cutting the skins) and test the two pieces separately. The final result is the sum of the strength from the two tests.

6.5 For method E

The test piece shall be cut out of the pipe in the circumferential direction and shaped to the dimensions shown in Figure 7, where the long sides are parallel to within 2 %. Alternatively, when it is required only to determine conformity to a minimum strength requirement, parallel-sided wide strips may be used. If, when using parallel-sided strips, the test piece fails before the minimum force is applied, the test shall be repeated using a test piece conforming to Figure 7.



Key

- | | | | |
|-----------|---|-----------|---|
| b | width of test section (between 24 mm and 26 mm) | b_{tot} | total width (48 mm min. to prevent shear failure), case 2 |
| b_s | free slot width (between 1 mm and 5 mm) | l | length of test piece (between 250 mm and 350 mm) |
| b_{tot} | total width, case 1 | a | Circumferential direction. |

Figure 7 — Test piece for restrained strip test (method E)

The test piece conforming to case 1 (see Figure 7) shall be used when helically wound reinforcing layers are not present or are present with a winding angle of $\theta > 70^\circ$. The test piece conforming to case 2 (see

[Figure 7](#)) shall be used when helically wound reinforcing layers with a winding angle of $\theta \leq 70^\circ$ are present.

The test width, b , shall be as specified in the referring standard, but not less than 10 mm.

NOTE For larger diameter and/or higher pressure pipe, the test width, b , might, for practical equipment reasons, need to be reduced.

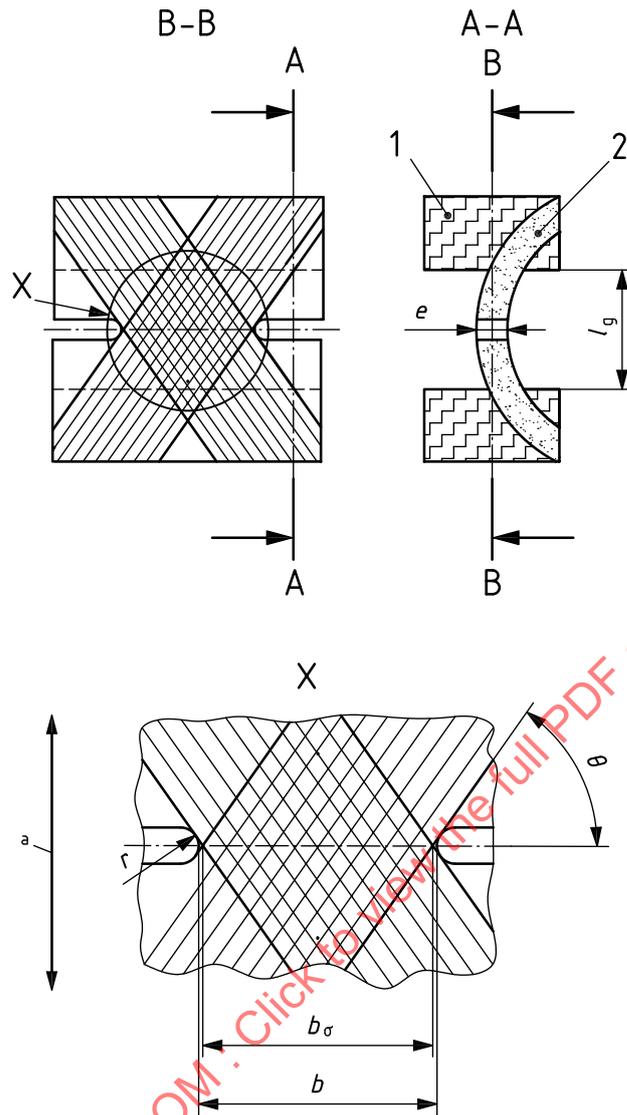
For case 2, the total width, b_{tot} , shall be as specified in the referring standard, but at least $2b$ to prevent shear failure.

If the test results from testing a sandwich wall construction show shear failure of the core of the specimen instead of tensile failure, then the results are invalid. In such cases it is allowed to make a new specimen, split the sample in two through the core (not cutting the skins) and test the two pieces separately. The final result is the sum of the load from the two tests.

6.6 For method F

The test piece shall be cut approximately square from the pipe, taking care that the reinforcement is properly oriented. The dimensions of the test piece shall be as specified in the referring standard, but sufficiently large to ensure that failure occurs across the neck of the test piece (see [Figure 8](#)).

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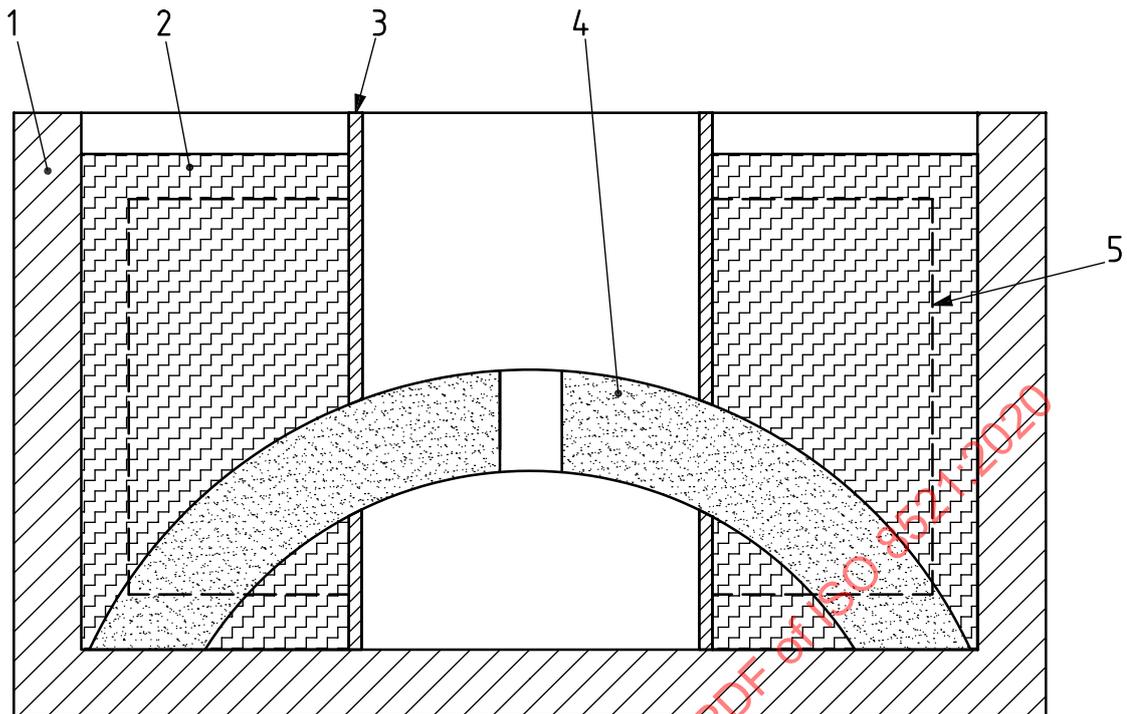


Key

- | | | | |
|----------|---|------------|---|
| 1 | thermosetting resin | b | width of neck, is equal to (min. 25 mm; max. $5e$) |
| 2 | pipe section test piece | r | radius within neck of test piece |
| l_g | distance between grips ($4 \times e$ min.) | b_σ | stressed width, $b + 2r(1 - 1/\sin \theta)$ |
| e | pipe wall thickness | a | Circumferential direction. |
| θ | winding angle, of glass fibres | | |

Figure 8 — Test piece for method F

The test piece ends shall be built up with 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 8](#) and [9](#)) will lie on the loading centreline of the test machine when gripped.

**Key**

- | | | | |
|---|---------------------|---|--------------------------------|
| 1 | outer mould | 4 | pipe section test piece |
| 2 | thermosetting resin | 5 | profile of ends after trimming |
| 3 | inner void former | | |

Figure 9 — Mould for resin application to test piece for method F

Any flash shall be removed, and the test piece shall be machined to the following dimensions (see [Figure 8](#)):

- distance between the grips, l_g : $l_g \geq 4e$;
- radius within the neck of the test piece, r : $0,2e \leq r \leq 0,5e$;
- width, b , of the neck: $25 \text{ mm} \leq b \leq 5e$.

6.7 Number of test pieces

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

7 Conditioning

Unless otherwise specified by the referring standard, store test pieces at the test temperature (see [Clause 8](#)) for at least 0,5 h prior to testing.

8 Test temperature

The test shall be conducted at the temperature specified in the referring standard.

9 Procedure

9.1 For method A

9.1.1 Determine the internal diameter, d_i .

9.1.2 Attach the end sealing devices to the test piece and fill the assembly with water. Attach the assembly to the pressurising system, taking care to avoid entrapment of air.

9.1.3 Pressurize at a rate such that failure occurs between 1 min and 3 min after starting to apply pressure. Record the maximum pressure reached, in bar, and the time to failure. For some nominal sizes greater than DN 500, the duration of the test will, for practical equipment reasons, need to be increased. Where increasing the testing time results in lower burst pressures, this shall be evaluated by comparing results of different test durations.

Because of the very high stresses (strains) generated by the pressures used to develop this ultimate strength, the discontinuity effects of the end closures can significantly influence the test results. The results of the test may be disregarded, and an additional sample tested, if the failure can clearly be determined to have occurred in a zone from the end closure of:

$$3,3 (DNe)^{0,5}$$

where

DN is the nominal size of the pipe, in millimetres;

e is the average wall thickness of the pipe, in millimetres.

9.1.4 If the modulus is to be measured, mark a circumferential line around a pipe sample at approximately the longitudinal centre of the sample and measure to an accuracy of 0,1 mm the average wall thickness of the pipe. Install three strain gauges, equally spaced on the marked line.

Attach the end sealing devices to the test piece and fill the assembly with water. Attach the assembly to the pressurising system, taking care to avoid entrapment of air. Pressurize the sample to a level of 1,5 PN while measuring the strain for the calculation of the modulus.

After completion of the strain measurements, depressurize the sample. Then test the sample for circumferential tensile wall strength according to [9.1.3](#).

9.2 For method B

9.2.1 Measure the width, b , of the test piece as the average of two measurements, one of which shall be taken at the inside surface of the ring in the notched area and the other at the outside surface of the ring in the notched area.

9.2.2 Mount the test piece on the outside periphery of the split disc with the expected failure zone (i.e. notched area) located on the surface of the split discs away from the separation of the two discs.

9.2.3 Apply a constant separating speed to the split disc such that failure occurs between 1 min and 3 min. Record the maximum force and the time to failure. Failures not occurring in the notched area shall be disregarded.