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Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial ring stiffness

Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Détermination de la rigidité annulaire initiale

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Foreword

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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 second edition cancels and replaces the first edition (ISO 7685:1998), which has been technically revised. The main changes compared to the previous edition are as follows:

— added recommendations for the parallelism of the plates/bars;

— added preload dependent on DN sizes;

— taring requirements of load and deflection after preload have been added and before start of testing.

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 plastics (GRP) pipes — Determination of initial ring stiffness

1 Scope

This document specifies methods for determining the initial ring stiffness of glass-reinforced thermosetting plastics (GRP) pipes. Two methods are given (constant load and constant deflection), and within the specified deflection limits, each is equally valid and can be used for any diameter.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

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
compressive load
F
load applied to a pipe to cause a diametric deflection

Note 1 to entry: Compressive load is expressed in newtons.

3.2
vertical deflection
y
vertical change in diameter of a pipe in a horizontal position in response to a vertical *compressive load* (3.1)

Note 1 to entry: Vertical deflection is expressed in metres.

3.3
relative vertical deflection
y/d_m
ratio of the *vertical deflection*, *y* (3.2) to the *mean diameter*, d_m (3.4) of the pipe

3.4
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, in metres, by either of the following formulae:

$$d_m = d_i + e$$

$$d_m = d_e + e$$

where

d_i is the internal diameter (see 6.3.4), in metres;

d_e is the external diameter (see 6.3.4), in metres;

e is the wall thickness of the pipe (see 6.3.3), in metres.

3.5
ring stiffness
S
physical characteristic of the pipe, which is a measure of the resistance to ring deflection under external load

Note 1 to entry: This characteristic is determined by testing and is defined, in newtons per square metre, by the formulae.

$$S = \frac{E \times I}{d_m^3}$$

where

E is the apparent modulus of elasticity as determined in the ring stiffness test, in newtons per square metre;

I is the second moment of area in the longitudinal direction per metre length, expressed in metres to the fourth power per metre, i.e.

$$I = \frac{e^3}{12}$$

where

e is the wall thickness of the test piece, in metres;

d_m is the mean diameter (see 3.4) of the test piece, in metres.

3.6
initial ring stiffness
S_0
initial value of *S* obtained by testing in accordance with this document

Note 1 to entry: Initial ring stiffness is expressed in newtons per square metre.

4 Principle

A specified length of pipe is loaded along its length to compress it diametrically. Two ways are given for doing this, Method A (constant load) and Method B (constant deflection), either of which can be used:

— Method A: After applying the load necessary to give a relative deflection of (3 ± 0,5) %, the load is kept constant for a specified period of time and the final deflection is determined at the end of this period.

— Method B: After applying the load necessary to give the initial relative deflection specified in the referring standard, the deflection is kept constant for a specified period of time and at the end of this period the final load being applied is determined.

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

a) the method to be used (A or B);

b) the length of the test pieces (see 6.1);

c) the number of test pieces (see 6.2);

d) if applicable, the details of conditioning of the test pieces (see Clause 7);

e) for Method B, the relative deflection to be applied (see 8.3.3).

5 Apparatus

5.1 Compressive-loading machine

Loading machine, comprising a system capable of applying, without shock, a compressive force (suitable for Method A or B) at a controlled rate through two parallel load application surfaces conforming to 5.2 so that a horizontally orientated pipe test piece conforming to Clause 5 can be compressed vertically. The accuracy of loading shall be ±1 % of the maximum indicated load.

5.2 Load application surfaces

5.2.1 General arrangement

The surfaces shall be provided by a pair of plates (see 5.2.2), or a pair of beam bars (see 5.2.3), or a combination of one such plate and one such bar, with their major axes perpendicular to and centred on the direction of application of the load F by the compressive-loading machine, as shown in Figure 1. The surfaces in contact with the test piece shall be flat, smooth, clean and parallel.

Plates and beam bars shall have a length at least equal to that of the test piece (see Clause 6) and a thickness such that visible deformation does not occur during the test.

Parallelism between the plates, beams, or plate and beams, at the centreline and along direction of axis of pipe is recommended to be within a gradient of 1 mm/m or 1:1 000. The parallelism is more critical for higher stiffness pipes. The parallelism should be verified at minimum pipe opening and at maximum pipe opening for the machine.

5.2.2 Plates

The plate(s) shall have a width of at least 100 mm.

5.2.3 Beam bars

Each beam bar shall have rounded edges, a flat face (see Figure 1) without sharp edges and a width dependent upon the pipe as follows:

a) for pipes with a nominal size not greater than DN 300, the width shall be 20 mm ± 2 mm;

b) for pipes of nominal sizes greater than DN 300, the width shall be 50 mm ± 5 mm.

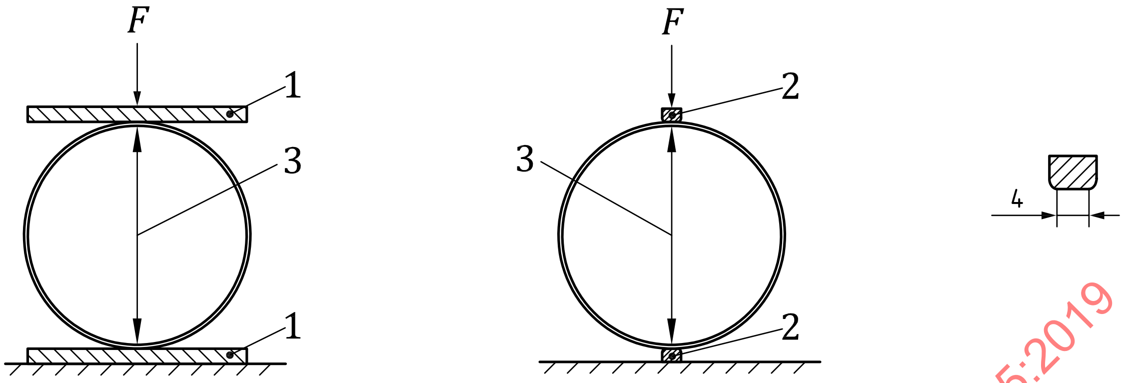
The beam bars shall be designed and supported such that no other surface of the beam bar structure comes into contact with the test piece during the test.

5.3 Dimension-measuring instruments

The dimension-measuring instruments should be calibrated with an accuracy as follows:

— to measure the necessary dimensions (length, diameter, wall thickness) instruments shall be calibrated to an accuracy of ±0,1 mm;

— to measure the deflection of the test piece in the vertical direction the instrument shall be calibrated to an accuracy of ±1,0 % of the maximum value.



a) Plate loading **b) Beam bar loading** **c) Detail of beam**

Key

1 plate
2 beam bar
3 deflection measurements at mid-length of test piece
4 width of the flat surface
F compressive load

Figure 1 — Schematic diagram of the test arrangement

6 Test pieces

6.1 Preparation

Each test piece shall be a complete ring cut from the pipe to be tested. The length of the test piece shall be as specified in the referring standard, with permissible deviations of ±5 %. Where a referring standard does not exist, or does not specify the length of the test piece, the length shall be 300 mm ± 15 mm.

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

Straight lines, to serve as reference lines, shall be drawn on the inside or the outside along the length of the test piece at 60° intervals around its circumference.

6.2 Number

The number of test pieces shall be as specified in the referring standard. Where a referring standard does not exist, or does not specify the number of test pieces, the said number shall be one per pipe size.

6.3 Determination of dimensions

6.3.1 General

The dimensions of the test piece shall be measured according to the methods given in ISO 3126, with the additional requirements in the following clauses.

6.3.2 Length

Measure the length of the test piece along each reference line.

Calculate the average length L, in metres, of the test piece from the six measured values.

6.3.3 Wall thickness

Measure the wall thickness of the test piece at each end of each reference line.

Calculate the average wall thickness e, in metres, of the 12 measured values.

6.3.4 Mean diameter

Measure either of the following:

a) the internal diameter d_i of the test piece between each pair of diametrically opposed reference lines at their mid length, e.g. by means of a pair of callipers;

b) the external diameter d_e of the test piece at the mid-points of the reference lines, e.g. by means of circumference tape (π-tape).

Calculate the mean diameter d_m of the test piece using the values obtained for wall thickness and either the internal or the external diameter (see 3.4).

7 Conditioning

Unless otherwise specified by the referring standard, store the test pieces for at least 0,5 h at the test temperature (see 8.1) prior to testing.

In cases of dispute, condition the test pieces for 24 h at 23 °C ± 5 °C before testing, or subject them to a mutually agreed conditioning schedule.

8 Procedure

8.1 Test temperature

Conduct the following procedure at the temperature specified in the referring standard.

8.2 Positioning of the test piece

Place a test piece in the apparatus with a pair of diametrically opposed reference lines in contact with the plate(s) and/or beam bar(s).

Ensure that the contact between the test piece and each plate or beam bar is as uniform as possible and that the plate(s) and/or beam bar(s) are not tilted laterally.

To ensure uniform contact, apply the following preload depending on the pipe size:

— for DN100 to DN450 preload to 15 N ± 5 N;

— for DN ≥ 500 preload to 100 N ± 10 N.

After applying preload, tare both deflection and load before proceeding with the test. Do not reduce load after being applied, due to possible backlash errors in the machine, contributing to displacement errors.

8.3 Application of load and measurement of deflection

8.3.1 General

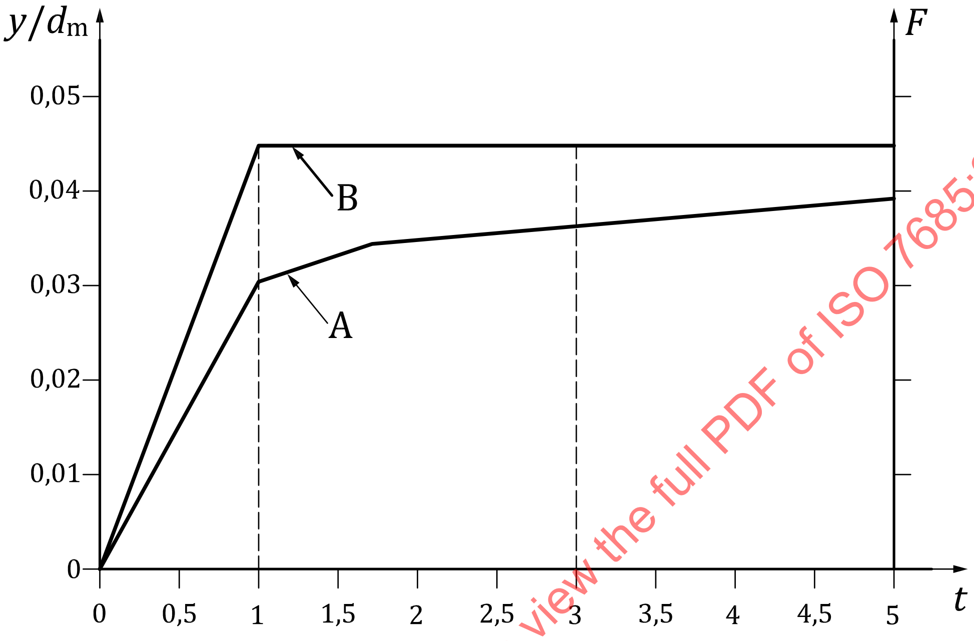
Carry out a test in accordance with 8.3.2 or 8.3.3 at each pair of reference lines (see 6.1). Allow the test piece to recover between each test. In cases of dispute, allow 15 min between each test.

8.3.2 Method A: Using constant load

See Figure 2.

Apply the compressive load at an approximately constant rate so that a relative deflection between 2,5 % and 3,0 % is reached in 60 s ± 10 s.

Keep this load constant for 2 min, and at the end of this period determine and record the load and the deflection.



Key

y/d_m	relative deflection	A	relative deflection
F	compressive load, in newtons	B	load; load held constant
t	time, in minutes		

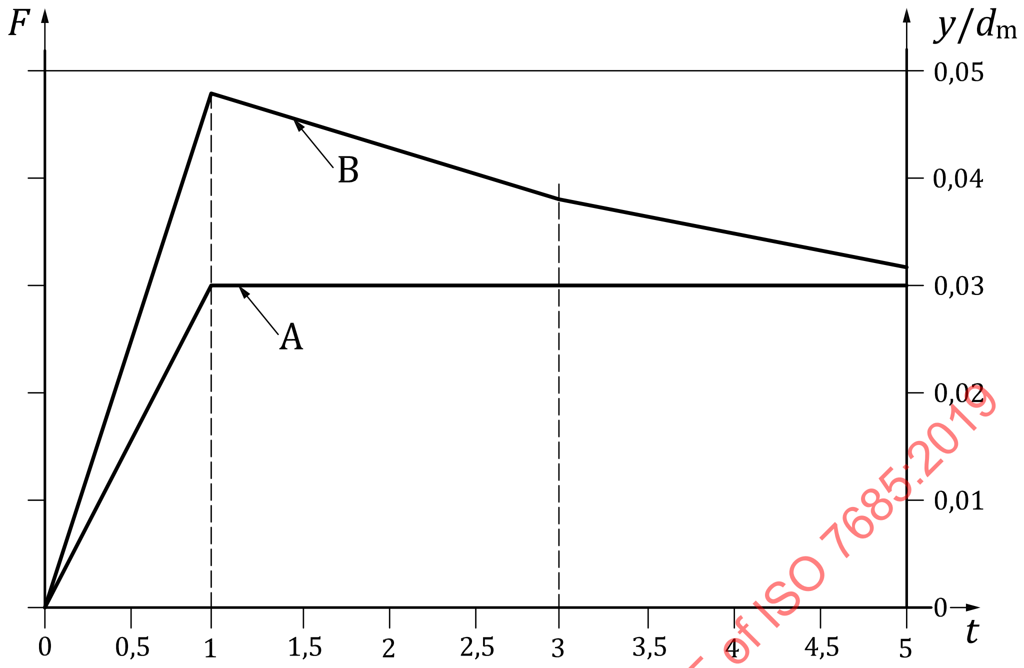
Figure 2 — Method A: Load and corresponding deflection versus time

8.3.3 Method B: Using constant deflection

See Figure 3.

Apply the compressive load at an approximately constant rate so that a relative deflection between 2,5 % and 3,0 % is reached in 60 s ± 10 s.

Keep this deflection constant for 2 min, and at the end of this period determine and record the deflection and the load.



Key

y/d_m relative deflection

F compressive load, in newtons

t time, in minutes

A relative deflection: deflection held constant

B load

Figure 3 — Method B: Deflection and corresponding load versus time

9 Calculation

Calculate the initial ring stiffness S_0 for each of the three positions using Formula (1):

$$S_0 = \frac{f \times F}{L \times y} \tag{1}$$

where

f is the deflection coefficient, given by the formula $f = \left[1\,860 + \left(2\,500 \times y / d_m\right)\right] \times 10^{-5}$;

L is the average length of the test piece, expressed in metres;

F is the applied load, expressed in newtons;

y is the deflection, expressed in metres;

d_m is the mean diameter, expressed in metres.

Calculate the average of the three values and record this value as the initial ring stiffness of the test piece.

NOTE This method for computing stiffness does not include the effects of shear deformations and is thus only valid for pipes with stiffness classes up to SN 10000.