
**Glass-reinforced thermosetting
plastics (GRP) pipes — Determination
of the ring creep properties under wet
or dry conditions**

*Tubes en plastiques thermodurcissables renforcés de verre (PRV) —
Détermination des propriétés de fluage annulaires en conditions
humides ou sèches*

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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 document 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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 155, *Plastics piping systems and ducting systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 10468:2018), which has been technically revised.

The main changes are as follows:

- the Introduction has been deleted as the information is no longer relevant to this edition of the document;
- in the test report, the “plot of measured deflection versus time” has been changed from an obligation into an option of plotting deflection versus time or stiffness versus time;
- initial ring stiffness according to ISO 7685 can now be measured by constant load or constant deflection.

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 the ring creep properties under wet or dry conditions

1 Scope

This document specifies methods for determining the ring creep properties for glass-reinforced thermosetting plastics (GRP) pipes. Properties include the creep factor and the long-term creep stiffness. Testing is performed under either wet (total immersion in water) or dry conditions.

Dry creep testing is typically performed for the assessment and control of raw material consistency. Wet creep testing is typically undertaken to determine the long-term creep performance in simulated use conditions.

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*

ISO 7685, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial ring stiffness*

ISO 10928:2016, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

vertical compressive force

F

vertical force, applied to a horizontal pipe to cause a *vertical deflection* (3.7)

Note 1 to entry: Vertical compressive force is expressed in Newtons.

3.2

ring stiffness

S

measure of the resistance of a pipe to ring deflection, per metre of length, under external load as defined by [Formula \(1\)](#):

$$S = \frac{E \times I}{d_m^3} \quad (1)$$

where

d_m is the *mean diameter* (3.3) of the pipe, in metres;

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

I is the second moment of area in the longitudinal direction per metre length, in metres to the fourth power per metre (m^4/m), as shown in [Formula \(2\)](#):

$$I = \frac{e^3}{12} \quad (2)$$

where e is the wall thickness of the pipe, in metres.

Note 1 to entry: Ring stiffness is expressed in Newtons per square metre.

3.3 mean diameter

d_m
diameter of the circle corresponding with the middle of the pipe wall cross-section and given by either [Formula \(3\)](#) or [Formula \(4\)](#):

$$d_m = d_i + e \quad (3)$$

$$d_m = d_e - e \quad (4)$$

where

d_i is the internal diameter, in metres;

d_e is the external diameter, in metres;

e is the wall thickness of the pipe, in metres.

Note 1 to entry: Mean diameter is expressed in metres.

3.4 initial ring stiffness

S_0
value of *ring stiffness*, S (3.2), determined by testing in accordance with ISO 7685

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

3.5 long-term ring creep stiffness at position 1

$S_{x,1,creep}$
value of *ring stiffness*, S (3.2), at a reference position, position 1, at x years, obtained by extrapolation of long-term stiffness measurements at a constant force ()

Note 1 to entry: See [10.2](#).

Note 2 to entry: Long-term ring creep stiffness at position 1 is expressed in Newtons per square metre.

3.6 creep factor

$\alpha_{x,creep}$
ratio of the long-term ring creep stiffness to the *initial ring stiffness* (3.4), both at a reference position, position 1 (see [10.2](#)), and given by [Formula \(5\)](#):

$$\alpha_{x,creep} = \frac{S_{x,1,creep}}{S_{0,1}} \quad (5)$$

where

$S_{0,1}$ is the ring stiffness at position 1, in Newtons per square metre at 0,1 h;

$S_{x,1,creep}$ is the *long-term ring creep stiffness at position 1* (3.5) at time x , in Newtons per square metre.

3.7

vertical deflection

y

vertical change in diameter of a pipe in a horizontal position, in response to a *vertical compressive force* (3.1)

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

3.8

long-term vertical deflection

$y_{x,1}$

value of the *vertical deflection, y* , (3.7) at the reference position, position 1 (see 10.2), at x years

Note 1 to entry: Long-term vertical deflection is expressed in metres.

3.9

deflection coefficient

f

dimensionless factor which takes into account general second-order theory as applied to deflection and is given by Formula (6):

$$f = [1\ 860 + (2\ 500 \times y_1 / d_m)] \times 10^{-5} \quad (6)$$

where

y_1 is the *long-term vertical deflection* (3.8) at position 1, in metres;

d_m is the *mean diameter* (3.3) of the pipe, in metres.

3.10

calculated strain

$\epsilon_{calc,1}$

strain on the inner surface at the crown and invert of a pipe at the reference position, position 1, given in percent by Formula (7):

$$\epsilon_{calc,1} = \frac{4,28 \times \frac{e}{d_m} \times \frac{y_1}{d_m} \times 100}{\left(1 + \frac{y_1}{2 \times d_m}\right)^2} \quad (7)$$

where

y_1 is the *vertical deflection* (3.7) at position 1, in metres;

d_m is the *mean diameter* (3.3) of the pipe, in metres;

e is the wall thickness of the pipe, in metres.

4 Principle

A cut length of pipe supported horizontally is loaded throughout its length to compress it diametrically to a prescribed level of strain calculated using [Formula \(7\)](#). The force application surfaces are either bearing plates or beam bars.

The pipe is subjected to a force which remains constant and the vertical deflection is measured at intervals. The long-term ring creep stiffness is estimated by extrapolation. For wet creep determinations the pipe is immersed in water at a given temperature.

The creep factor is then determined from the long-term ring creep stiffness and the ring stiffness of the same test piece at 0,1 h. The declared creep factor is the average of the results from two test pieces.

It is assumed that values for the following test parameters will be set by the referring standard:

- a) the time to which the values are to be extrapolated (see [3.6](#) and [11.1](#));
- b) the test temperature (see [5.3](#) and [10.1](#));
- c) the length of the test piece (see [Clause 6](#));
- d) if applicable, the conditioning parameters, i.e. temperature, humidity and duration (see [Clause 9](#));
- e) the time limits for maintaining the test piece under load (see [10.6](#));
- f) the level of strain at which the test is to be conducted;
- g) whether the testing is to be conducted in wet or dry conditions.

5 Apparatus

5.1 Compressive loading machine

The machine shall comprise a system capable of applying a force, without shock, through two parallel force application surfaces in accordance with [5.2](#) so that a horizontally orientated test piece of pipe in accordance with [Clause 6](#), immersed in water if applicable, can be compressed vertically and maintained under a constant force for the duration of the test in accordance with [10.6](#).

Equipment shall be capable of determining the force applied to within ± 1 % of the value to be applied.

Ensure that the applied force is not affected by buoyancy effects for wet creep testing, or friction.

5.2 Force application surfaces

5.2.1 General arrangement

The method allows the use of either bearing plates or beam bars for loading the test piece, subject to reporting the choice used. The same loading arrangement (plates, bars, or plate and bar) shall be used for the determination of both initial and long-term stiffness.

The surfaces shall be provided by a pair of plates, in accordance with [5.2.2](#), or a pair of beam bars, in accordance with [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 force F , exerted by the compressive loading machine, as shown in [Figure 1](#). The surfaces to be in contact with the test piece shall be flat, smooth, clean and parallel.

5.2.2 Plates

The plate(s) shall have a width of at least 100 mm and a length at least equal to the length of the test piece (see [Clause 6](#)). They shall be sufficiently stiff so that they do not visibly bend or otherwise deform during the test.

5.2.3 Beam bars

Each beam bar shall be sufficiently stiff that it does not visibly bend or otherwise deform during the test. Each beam bar shall have a length at least equal to the length of the test piece (see [Clause 6](#)) and a flat face (see [Figure 1](#)) without sharp edges. The width of the flat face shall be 15 mm to 55 mm.

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

5.3 Water container

If testing under wet conditions,, a container large enough to accommodate the submerged test pieces in accordance with [Clause 6](#) while they are subject to the compressive force in accordance with [10.5](#), and containing tap water having a pH of 7 ± 2 and kept at the specified temperature (see [10.1](#)).

The water level shall be maintained sufficiently constant to avoid any significant effect on the value of the vertical force applied to the test piece.

5.4 Measuring devices

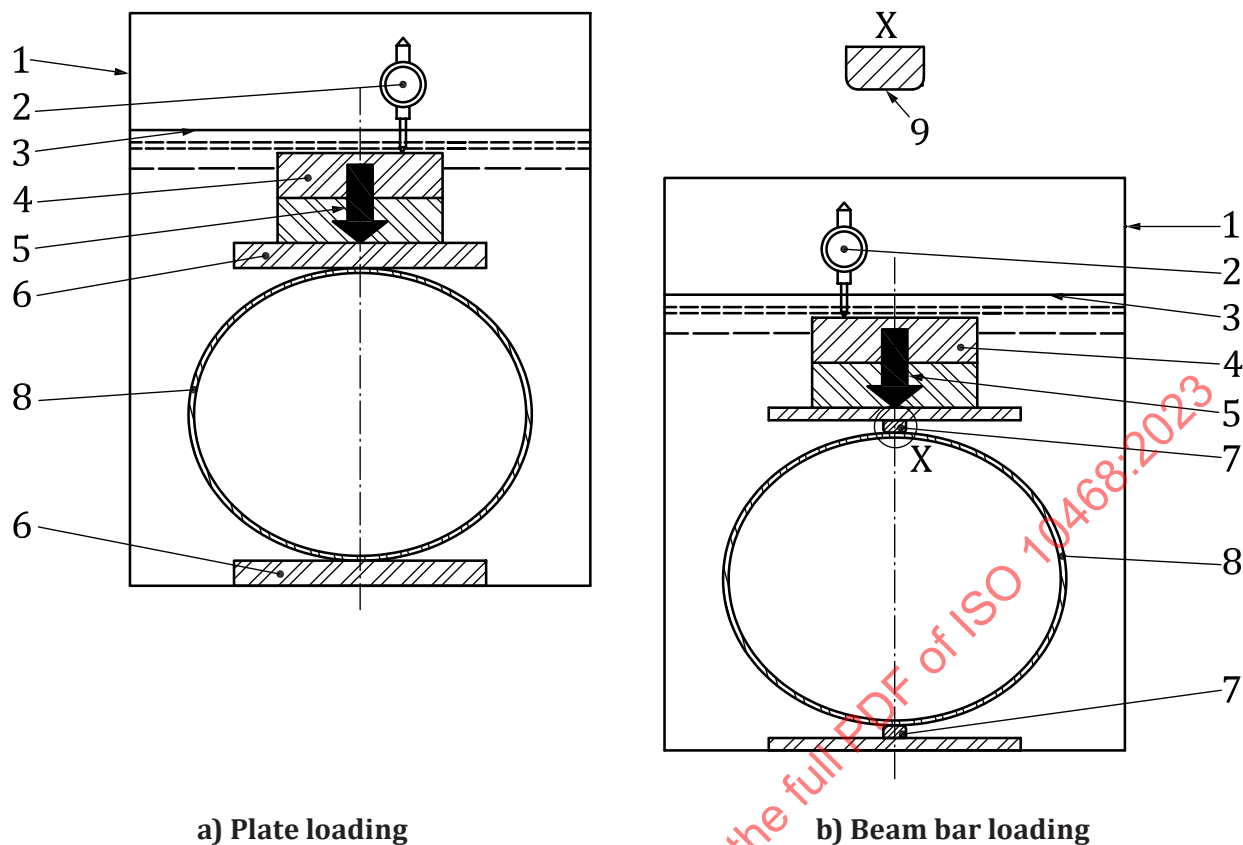
The requirements for the measuring devices are as follows:

- a) The devices used to measure dimensions (length, diameter, wall thickness) as specified in [Clause 8](#) shall have a calibrated accuracy of within ± 1 % of the dimension being measured.
- b) The devices used to measure deflection of the test piece in the vertical direction during the test shall have a calibrated accuracy of within ± 1 % of the initial deflection value.
- c) The devices used to measure load shall have a calibrated accuracy of ± 1 % of the value applied.

When selecting the device to measure the change in diameter of the test piece, consideration should be given to the potentially corrosive environment in which the device is to be used.

6 Test piece

The test piece shall be a complete ring. The length, L , in metres, of the test piece shall be as specified in the referring standard, subject to permissible deviations of ± 5 %. If not specified in the referring standard, the length of the test piece shall be (300 ± 15) mm.



Key

- 1 water container
- 2 deflection-measuring device
- 3 water level
- 4 dead-weights
- 5 direction of compressive force, F

- 6 bearing plate
7 beam bar
8 test piece
9 flat face

NOTE 1 For wet creep testing it is permissible for the device for measuring deflection, the dead-weights, and the bearing plate and beam bar above the test piece to be located above the water level, providing the test piece is completely immersed for the duration of the test.

NOTE 2 The test arrangements shown include a water container as would be used for wet creep testing. For dry creep testing the test arrangements are the same except for the elimination of the water and container.

Figure 1 — Typical creep test arrangements

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

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

7 Number of test pieces

Two test pieces shall be used (see also [11.3](#)).

8 Determination of the dimensions of the test pieces

The dimensions of the test pieces (length, thickness and mean diameter) shall be determined in accordance with ISO 3126.

9 Conditioning

If applicable, condition the test pieces in accordance with the referring standard.

10 Procedure

10.1 For each test piece conduct the following procedure at the temperature specified in the referring standard.

10.2 Determine and record in accordance with ISO 7685 the initial ring stiffness, S_0 , of the test piece. Use the measured value of S_0 at a pair of reference lines, to be designated “position 1”, to estimate the force required to compress the test piece to the necessary deflection within 3 min to achieve, unless specified otherwise in the referring standard, a calculated strain (see 3.10) between 0,13 % and 0,17 %.

10.3 Place the test piece in the apparatus in contact with the upper and lower plate or the beam bars, with the pair of diametrically opposed reference lines designated “position 1”, in accordance with 10.2, vertically aligned. Ensure that the contact between the test piece and each bearing plate or beam bar is as uniform as possible and the plates and/or beam bars are not tilted laterally. For wet conditions place the apparatus in the water container.

10.4 If testing in wet conditions, fill the container with water so that the test piece is fully immersed.

10.5 When the test piece is fully immersed in the water, if applicable, and taking account, as necessary, of the mass of the upper plate or beam bar, apply the vertical compressive force, F , estimated in accordance with 10.2 so that the corresponding vertical deflection is reached within 3 min and record the actual force applied and deflection achieved.

10.6 Hold the force constant throughout the duration of the test. Commencing at not more than 1 h after loading and continuing for the specified time, (for the determination of wet creep modulus more than 10 000 h), measure and record, to within 2 % of the initial value, the deflection of the test piece at approximately equal intervals of $\lg$ (time) after loading. The intervals shall be such that 10 approximately equally spaced readings are taken for each decade of $\lg$ (time in h).

11 Calculation

11.1 Extrapolation of the deflection data

If required by the referring standard, use the data obtained in accordance with 10.6, and plot $\lg$ (deflection) as a function of $\lg$ (time) and/or plot $\lg$ (stiffness) as a function of $\lg$ (time).

From the measured deflections and corresponding time intervals between 1 h and over 10 000 h, calculate for each test piece the ring stiffness for position 1 using Formula (8):

$$S_{x,1,\text{creep}} = \frac{f \times F}{L \times y_{x,1}} \quad (8)$$