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Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor

Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Détermination de la rigidité annulaire spécifique à long terme en fluage en conditions mouillées et calcul du facteur de fluage mouillé

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Foreword

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The main task of technical committees is to prepare International Standards. 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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Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor

1 Scope

This International Standard specifies a method for determining both the long-term specific ring creep stiffness and the wet creep factor for glass-reinforced thermosetting plastics (GRP) pipes.

2 Normative references

The following referenced documents are indispensable for the application 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 7685:1998, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness*

ISO 10928:1997, *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.

3.1
vertical compressive force
F
vertical force, expressed in newtons, applied to a horizontal pipe to cause a vertical deflection

3.2
specific ring stiffness
S
physical characteristic of a pipe, expressed in newtons per square metre, that is a measure of the resistance to ring deflection per metre length under external load and is defined by Equation (1):

$$S = \frac{E \times I}{{d_m}^3} \tag{1}$$

where

E is the apparent modulus of elasticity, in newtons per square metre, determined by testing in accordance with ISO 7685;

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), i.e.

$$I = \frac{e^3}{12} \tag{2}$$

e being the wall thickness of the pipe, in metres;

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

3.3
mean diameter
d_m
diameter, expressed in metres, of the circle corresponding with the middle of the pipe wall cross-section and given by either of the following equations:

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

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

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.

3.4
initial specific ring stiffness
S_0
value of S, expressed in newtons per square metre, determined by testing in accordance with ISO 7685

3.5
long-term specific ring creep stiffness at position 1
$S_{x,\ 1,\ \text{creep, wet}}$

value of S, expressed in newtons per square metre, at a reference position, position 1 (see 10.2), at x years, obtained by extrapolation of long-term stiffness measurements at a constant force under wet conditions (see 3.2 and 10.2)

3.6
calculated long-term specific ring creep stiffness under wet conditions
$S_{x,\ \text{creep, wet}}$
calculated value of S, expressed in newtons per square metre, at x years obtained using Equation (5):

$$S_{x,\ \text{creep, wet}} = S_0 \times \alpha_{x,\ \text{creep, wet}} \quad (5)$$

where

x is the elapsed time, in years, specified in the referring standard;

$\alpha_{x,\ \text{creep, wet}}$ is the wet creep factor (see 3.7);

S_0 is the initial specific ring stiffness, in newtons per square metre.

3.7
wet creep factor
$\alpha_{x,\ \text{creep, wet}}$
ratio of the long-term specific ring creep stiffness to the initial specific ring stiffness, both at a reference position, position 1 (see 10.2), and given by Equation (6):

$$\alpha_{x,\ \text{creep, wet}} = \frac{S_{x,\ 1,\ \text{creep, wet}}}{S_{0,\ 1}} \quad (6)$$

where

$S_{0,\,1}$ is the initial specific ring stiffness at position 1, in newtons per square metre, determined in accordance with ISO 7685;

$S_{x,\,1,\,\text{creep, wet}}$ is the long-term specific ring creep stiffness at position 1, in newtons per square metre.

3.8
vertical deflection
y
vertical change in diameter of a pipe in a horizontal position, expressed in metres, in response to a vertical compressive force (see 3.1)

3.9
long-term vertical deflection
$y_{x,\,1,\,\text{wet}}$
value of the vertical deflection y, expressed in metres, at the reference position, position 1 (see 10.2), at x years under wet conditions

3.10
deflection coefficient
f
dimensionless factor which takes into account general second-order theory as applied to deflection and is given by Equation (7):

$$f = \left[1\,860 + \left(2\,500 \times y_1 / d_m\right)\right] \times 10^{-5} \tag{7}$$

where

y_1 is the long-term vertical deflection at position 1, in metres;

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

3.11
calculated strain
$\varepsilon_{\text{calc},\,1}$
strain on the inner surface at the crown and invert of a pipe at the reference position, position 1, given in percent by Equation (8):

$$\varepsilon_{\text{calc},\,1} = \frac{4{,}28 \times \dfrac{e}{d_m} \times \dfrac{y_1}{d_m} \times 100}{\left(1 + \dfrac{y_1}{2 \times d_m}\right)^2} \tag{8}$$

where

y_1 is the vertical deflection at position 1, in metres;

d_m is the mean diameter of the pipe (see 3.3), 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 Equation 8. The force application surfaces are either bearing plates or beam bars.

The pipe is immersed in water at a given temperature for a period of time during which the force remains constant and the vertical deflection is measured at intervals. The long-term specific ring creep stiffness is estimated by extrapolation.

The wet creep factor is then determined from the long-term specific ring creep stiffness and the initial specific ring stiffness of the same test piece. The declared wet creep factor is the average of the results from two test pieces.

NOTE It is assumed that values for the following test parameters will be set by the standard making reference to this International Standard:

a) the method for measuring the initial specific ring stiffness, i.e. method A or B of ISO 7685:1998 (see 3.4);

b) the time to which the values are to be extrapolated (see 3.6 and 11.1);

c) the test temperature (see 5.3 and 10.1);

d) the length of the test piece (see Clause 6);

e) if applicable, the conditioning parameters, i.e. temperature, humidity and duration (see Clause 9);

f) the time limits for maintaining the test piece under load (see 10.6);

g) the level of strain at which the test is to be conducted.

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 conforming to 5.2 so that a horizontally orientated test piece of pipe conforming to Clause 6 and immersed in water can be compressed vertically and maintained under a constant force for the duration of the test in accordance with 10.6.

Equipment shall be available for determining the force applied to within ± 1 %.

Ensure that the applied force is not affected by buoyancy effects or friction.

5.2 Force application surfaces

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.

5.2.1 General arrangement

The surfaces shall be provided by a pair of plates, conforming to 5.2.2, or a pair of beam bars, conforming to 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 so constructed and supported that no other surface of the beam bar structure comes into contact with the test piece during the test.

5.3 Water container

Required is a container large enough to accommodate submerged test pieces conforming to Clause 6 whilst 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

Required are devices capable of determining:

a) the necessary dimensions (length, diameters, wall thickness) to an accuracy within that specified in Clause 8, as applicable;

b) the deflection of the test piece in the vertical direction during the test to an accuracy within ± 1,0 % of the initial value.

NOTE 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.

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.