INTERNATIONAL STANDARD

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Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the creep factor under dry conditions

Systèmes de canalisations en matières plastiques — Tubes plastiques thermodurcissables renforcés de verre (PRV) — Détermination du coefficient de fluage en condition sèche

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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.

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.

International Standard ISO 7684 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 International Standard is technically identical to EN 761:1994.

Annex A of this International Standard is for information only.

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Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the creep factor under dry conditions

1 Scope

This International Standard specifies a method for determining the dry creep factor of glass-reinforced plastics pipes.

It is applicable to pipes with an initial specific ring stiffness of not less than 630 N/m^2, when determined by the method specified in the referring standard.

NOTE - For this purpose plates or beam bars are considered to be equally valid for loading the test piece up to a relative deflection of 28 %. When it is expected that the relative deflection will be more than 28 %, then the test is to be conducted using beam bars (see 8.3).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7685:—[1)] *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness*

ISO 10928:—[1)] *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

1) To be published

3 Definitions

For the purposes of this International Standard, the following definitions apply:

3.1 specific ring stiffness (*S*): A physical characteristic of the pipe which is a measure of the resistance to ring deflection under external load.

This characteristic is determined by testing and is defined, in newtons per square metre, by the equation:

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

where

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

I is the moment of inertia (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 pipe, in metres;

d_m is the mean diameter (see 3.2) of the pipe, in metres.

3.2 mean diameter (d_m): The diameter of the circle corresponding to the middle of the pipe wall cross section.

It is given, in metres, by either of the following equations:

$$d_m = d_i + e$$

$$d_m = d_e - e$$

where

d_i is the average of the measured internal diameters, in metres;

d_e is the average of the measured external diameters, in metres;

e is the average of the measured wall thicknesses of the pipe, in metres.

3.3 initial specific ring stiffness (S_0): The specific ring stiffness when measured 3 min after the beginning of loading.

It is expressed in newtons per square metre.

3.4 compressive load (F): A load applied to the horizontal pipe to cause a vertical deflection.

It is expressed in newtons.

3.5 vertical deflection (y): The vertical change in diameter of a pipe in a horizontal position in response to a vertical compressive load (see 3.4).

It is expressed in metres.

3.6 initial deflection (y_{3min}): The vertical deflection caused by the compressive load and measured 3 min (i.e. 0,05 h) after the beginning of loading.

It is expressed in metres.

3.7 long-term vertical deflection under dry conditions ($y_{x,dry}$): The estimated vertical deflection after x years, obtained by extrapolation of long-term deflection measurements at a constant load under dry conditions.

It is expressed in metres.

3.8 dry conditions: The test environment in air at the prevailing humidity.

3.9 dry creep factor ($\alpha_{x,dry}$): The factor given by the following equation:

$$\alpha_{x,dry} = \frac{y_{3\,min}}{y_{x,dry}} \times \frac{f_x}{f_{3\,min}}$$

where

x indicates a specified period of time, in years;

f is the applicable deflection coefficient.

3.10 deflection coefficient (f): The coefficient which takes into account the 2nd order theory and of which the value is given by the following equation:

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

4 Principle

A cut length of pipe is subjected to a constant load along its length to compress it diametrically for a period of not less than 1 000 h. Its deflection is measured at intervals. The deflection after a specified time of *x* years is estimated by extrapolation.

The creep factor under dry conditions is determined from the relationship between the initial deflection and the deflection after *x* years of the same test piece (see 3.7 and 3.8).

NOTES

1 If it is required to predict the deflection at 50 years, this requires extrapolating approximately 2,5 decades (2,5 increments of lg*t*, where *t* is time in hours). In order to improve the reliability of the prediction the creep test may be extended beyond 1 000 h.

2 It is assumed that the following test parameters are set by the standard making reference to this International Standard:

a) the time to which the values are to be extrapolated (see 3.6, 3.7, 3.9 and clause 9);

b) the length of each test piece (see 6.1);

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

d) if applicable, the conditioning atmosphere and period (see clause 7);

e) the test temperature and relative humidity (see 8.1);

f) the periods of test pieces under load (see 8.4).

5 Apparatus

5.1 Compressive loading machine, comprising a system by means of which one or more test pieces can be compressed by compressive load determined to an accuracy of 1 % of the maximum indicated applied value via two parallel load application surfaces conforming to 5.2.

NOTE - Care may be necessary to ensure that the applied load is not affected by friction effects.

5.2 Load application surfaces

5.2.1 General

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 the load *F* 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.

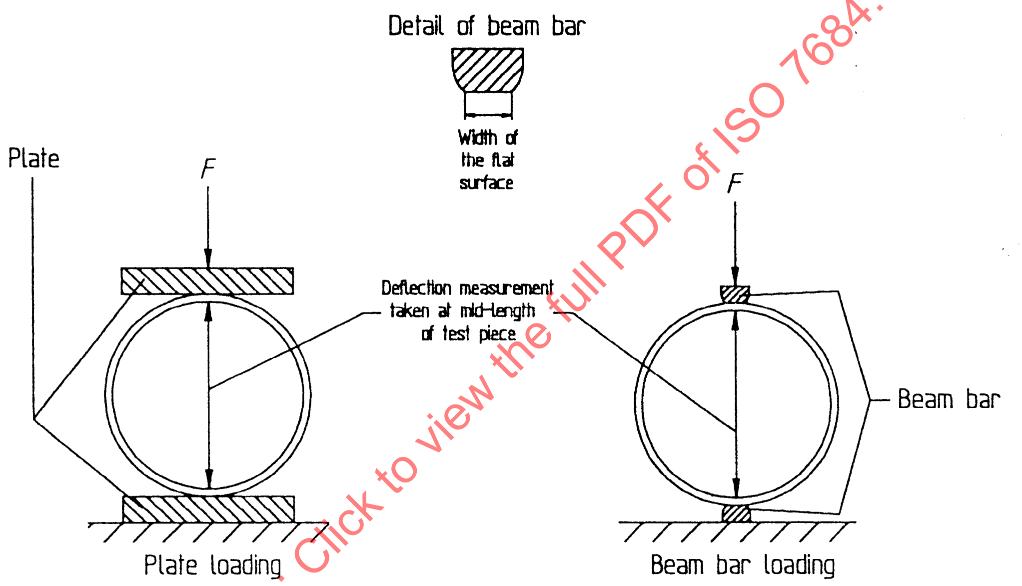

Figure 1 – Schematic diagram of the apparatus

5.2.2 Plate

Each plate shall have a length at least equal to the length of the test piece (see 6.1), a width of at least 100 mm and a thickness such that no visible bending or deformation of the plate shall occur during the test.

5.2.3 Beam bar

Each beam bar shall be rigid, shall have rounded edges and shall have a length at least equal to the length of the test piece (see 6.1). For pipes with a nominal size of not more than 300, the width of the bar shall be (20 ± 5) mm. For pipes with a nominal size greater than 300, the width of the bar shall be (50 ± 5) mm. Each bar shall be so constructed and supported that other surfaces of the beam bar structure shall not come into contact with the test piece during the test.

5.3 Dimensional measuring devices, capable of determining the necessary dimensions (length, diameters, wall thickness) to an accuracy of within ±1 % and of determining the change in diameter of the test piece in the vertical direction during the test to an accuracy of within ±1 % of the maximum value of the measured change.

NOTE - The maximum value of the change to be measured depends upon the relative deflection specified in the referring standard.

6 Test piece

6.1 Preparation

The 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 %.

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

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.

6.2 Number

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

6.3 Determination of the dimensions

6.3.1 Length

Measure the length of the test piece along each reference line to an accuracy of ±0,5 %.

Calculate the average length, L, of the test piece, in metres.

Reject or correct the test piece if it does not conform to 6.1.

6.3.2 Wall thickness

Measure to within ±1 % the wall thickness of the test piece at each end of each reference line.

Calculate the mean wall thickness, *e*, as the average of the measured values.

6.3.3 Mean diameter

Measure to an accuracy of within ±1,0 % either of the following:

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

b) the external diameter, d_e, of the test piece which includes the mid-points of the reference lines, e.g. by means of a circumferential wrap steel tape.

Determine the mean diameter, d_m, of the test piece by calculation using the averaged values obtained for wall thickness and for either the average internal or the average external diameter at the mid-point of the six reference lines (see 6.1).

7 Conditioning

Store the test pieces at the test temperature and relative humidity specified in the referring standard prior to testing.

NOTE - The age and storage conditions (temperature and relative humidity) of the test pieces can affect the results of the creep test.

8 Procedure

8.1 Test temperature and relative humidity

Conduct the tests at the temperature and relative humidity specified in the referring standard.

8.2 Determination of the compressive load

Determine and record in accordance with ISO 7685 the initial specific ring stiffness, S_0, of the test piece. Use the determined value of the initial specific ring stiffness for one diameter, which includes a pair of reference lines, to be designated "position 1", to estimate the load F required to compress the test piece by between 1,5 % and 2 % of its mean diameter, d_m.

8.3 Positioning of the test piece

If the applied load is expected to cause a relative deflection in excess of 28 %, use beam bars for contact with the test piece, otherwise use either plates or beam bars.

Place the test piece in the apparatus with the pair of reference lines designated "position 1" (see 8.2) in contact with the upper and lower plate(s) 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.

8.4 Application of the compressive load and measurement of deflection

Taking account of the mass of the upper plate or beam bar, apply the vertical compressive load, F, estimated in accordance with 8.2, so that the corresponding vertical deflection is reached within 3 min. Record the actual deflection achieved.

Maintain this load for the period specified by the referring standard. During this period, measure and record to within ±1 % of the measured value the vertical deflection at mid-length of the test piece at specified time intervals after loading such that at least three readings are taken for each decade of the logarithm of the time in hours.

NOTE – In table A.1, values of equal increments of lg$t$ (t is time in hours) are given which may be useful to the observer.

9 Calculation

9.1 Extrapolation of the long-term deflection data for position 1 to obtain the *x*-year value $y_{x,1,dry}$

Using the data obtained in accordance with 8.3 and 8.4, plot deflection as a function of time as specified in the referring standard.

From the series of measured deflections and corresponding time intervals, determine, in accordance with method B of ISO 10928, the first order polynomial

$$\lg y_t = a + b \times \lg t \qquad \dots (1)$$

where

y_t is the calculated deflection, in metres, at time t for $0{,}05\ \text{h} \leqslant t \leqslant 1\ 000\ \text{h}$;

a is the logarithm of the calculated deflection at time t = 1 h ($a = \lg y_{1h,1}$);

b is the slope of the line;

t is the time interval between 0,05 h and 1 000 h.

Calculate the logarithm of the extrapolated deflection at x years using the calculated values of a and b in the following equation:

$$\lg y_{x,1,dry} = a + b \times \lg t_x \qquad \dots (2)$$

where

$y_{x,1,dry}$ is the extrapolated deflection for position 1 at x years under dry conditions, in metres;

t_x is the time x years, in hours.

9.2 Calculation of the creep factor under dry conditions

Calculate the creep factor under dry conditions, $\alpha_{x,dry}$, using the following equation:

$$\alpha_{x,dry} = \frac{y_{3min,1}}{y_{x,1,dry}} \times \frac{f_x}{f_{3min}} \qquad \dots (3)$$

where

$y_{3min,1}$ is the calculated deflection for position 1 at time t = 3 min (i.e. 0,05 h), in metres;

$y_{x,1,dry}$ is the extrapolated deflection for position 1 at the time specified in the referring standard, in metres;

f_{3min} is the deflection coefficient for the deflection at time t = 3 min (i.e. 0,05 h) and has the value given by

$[1\ 860 + (2\ 500 \times y_{3min,1}/d_m)] \times 10^{-5}$;

f_x is the deflection coefficient for the deflection at the time x specified in the referring standard and has the value given by

$$[1\ 860 + (2\ 500 \times y_{x,1,dry}/d_m)] \times 10^{-5}.$$

10 Test report

The test report shall include the following information:

a) a reference to this International Standard and the referring standard;

b) the full identification of the pipe tested;

c) the dimensions of each test piece;

d) the number of test pieces;

e) the positions in the pipe from which the test pieces were obtained;

f) the equipment details, including whether beam bars and/or plates were used;

g) the temperature and relative humidity during testing;

h) the creep factor under dry conditions, $\alpha_{x,dry}$, for each test piece;

i) the initial specific ring stiffness, S_0, and the initial specific ring stiffness at position 1, $S_{0,1}$, for each test piece;

j) the deflection at which S_0 was determined;

k) the initial deflection;

l) the calculated deflection, $y_{3min,1}$, at time t = 3 min (i.e. 0,05 h) for each test piece;

m) the extrapolated deflection, $y_{x,1,dry}$, at the specified time under dry conditions for each test piece;

n) a description of the test pieces after testing;

o) the age from the time of manufacture of the pipe to the start of the test and the conditions of storage during that period (temperature and relative humidity);

p) any factors which may have affected the results, such as any incidents or any operating details not specified in this International Standard;

q) the dates of the testing period.