INTERNATIONAL STANDARD

ISO 9967

First edition
1994-03-01

Thermoplastics pipes — Determination of creep ratio

Tubes en matières thermoplastiques — Détermination du taux de fluage

Reference number
ISO 9967:1994(E)

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 9967 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Sub-Committee SC 1, *Plastics pipes and fittings for soil, waste and drainage (including land drainage)*.

Annexes A and B of this International Standard are for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Introduction

Experience shows that, when a pipe is installed in the ground in accordance with an appropriate code of practice, its increase in deflection virtually stops after a short period. This period varies depending on the soil and installation conditions, but it does not exceed two years.

Therefore the two-year creep ratio as determined in accordance with this International Standard is intended for use when long-term static calculations are carried out.

The theory of creep in thermoplastics materials is briefly explained in annex A.

For experiments, the test can be carried out based on other ages of the test pieces, other test temperatures and/or other testing times.

This page intentionally left blank

Thermoplastics pipes — Determination of creep ratio

1 Scope

This International Standard specifies a method of determining the creep ratio of thermoplastics pipes having a circular cross-section.

2 Symbols

The following symbols are used in this International Standard:

		Units
d_n	nominal diameter of pipe	mm
d_i	inside diameter of pipe test piece	m
F	loading force	kN
F_0	pre-load force	N
L	length of test piece	m
y_0	measured initial deflection	m
Y_t	calculated deflection at time t	m
Y_2	extrapolated two-year deflection	m
δ	vertical deflection used to determine the loading force	m
γ	creep ratio	

3 Principle

A cut length of pipe is placed between two parallel flat horizontal plates and a constant compressive force is applied for 1 000 h (42 days).

The deflection of the pipe is recorded at specified intervals so as to prepare a plot of pipe deflection against time. The linearity of the data is analysed and the creep ratio is calculated.

4 Apparatus

4.1 Compressive-testing machine, capable of applying to the pipe via plates (4.2), and maintaining to within 1 %, both the applicable pre-load force F_0 (see 7.4) and the necessary loading force F (see 7.5).

4.2 Two steel plates, through which the compressive force can be applied to the test piece. The plates shall be flat, smooth and clean and shall not deform during the test to an extent that would affect the results.

The length of each plate shall be at least equal to the length of the test piece. The width of each plate shall be not less than the maximum width of the surface in contact with the test piece while under load plus 25 mm.

4.3 Measuring devices, capable of determining

— the length of the test piece to within 1 mm (see 5.2);

— the inside diameter of the test piece to within 0,5 %;

— the change in inside diameter of the test piece in the direction of loading with an accuracy of 0,1 mm, or 1 % of the deflection, whichever is the greater.

An example of a device for measuring the inside diameter of corrugated pipes is shown in figure 1.

4.4 Timer.

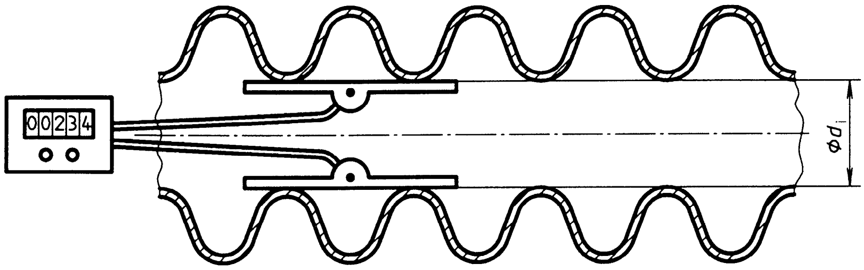


Figure 1 — Example of a device for measuring the inside diameter of a corrugated pipe

5 Test pieces

5.1 Marking and number of test pieces

The pipe for which the creep ratio is to be determined shall be marked on the outside along its full length with a line along one generatrix. Three test pieces, **a**, **b** and **c**, respectively, shall be taken from this marked pipe such that the ends of the test pieces are perpendicular to the pipe axis and their lengths conform to 5.2.

5.2 Length of test pieces

5.2.1 The length of each test piece shall be determined by calculating the arithmetic mean of three to six length measurements equally spaced around the perimeter of the pipe as given in table 1. The length of each test piece shall conform to 5.2.2, 5.2.3, 5.2.4 or 5.2.5, as applicable.

Each of the three to six length measurements shall be made to within 1 mm.

For each individual test piece, the smallest of the three to six length measurements shall not be less than 0,9 times the largest measurement.

Table 1 — Number of length measurements

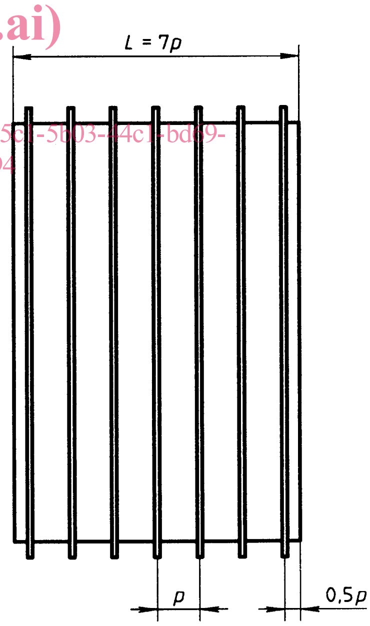
Nominal diameter d_n of the pipe mm	Number of length measurements
$d_n \leqslant 200$	3
$200 < d_n < 500$	4
$d_n \geqslant 500$	6

5.2.2 For pipes that have nominal diameters less than or equal to 1 500 mm, the average length of each test piece shall be 300 mm ± 10 mm.

5.2.3 For pipes that have nominal diameters greater than 1 500 mm, the average length, in millimetres, of each test piece shall be at least $0{,}2d_n$.

5.2.4 Structured-wall pipes with perpendicular ribs or corrugations or other regular structures shall be cut such that each test piece contains the minimum whole number of ribs, corrugations or other structures necessary to satisfy the requirement on length given in 5.2.2 or 5.2.3, as applicable (see figure 2).

The cuts shall be made at the mid-point between the ribs, corrugations or other structures.

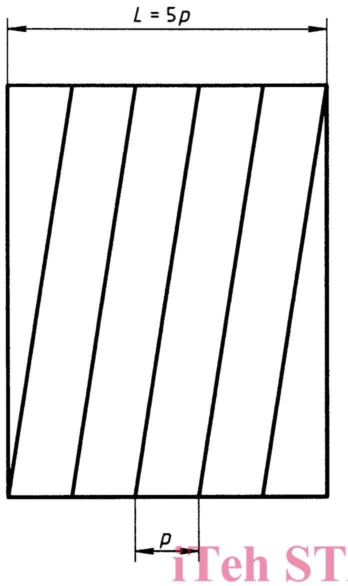


e.g. $p = 45$ mm

Figure 2 — Test piece cut out of a perpendicularly ribbed pipe

5.2.5 For helically wound pipes (see figure 3), the length of each test piece shall be such that it contains the minimum whole number of helical windings necessary to satisfy the requirement on length given in 5.2.2 or 5.2.3, as applicable.

For pipes with helical stiffeners in the form of ribs, corrugations, etc., the length of each test piece shall be such that it comprises a whole number of stiffeners, with a minimum of three, and shall conform to 5.2.2 or 5.2.3, as applicable.



e.g. $p = 65$ mm

Figure 3 — Test piece cut out of a helically wound pipe

5.3 Inside diameter of test pieces

Determine the inside diameters d_{ia}, d_{ib} and d_{ic} of the respective test pieces **a**, **b** and **c** (see 5.1) as the arithmetic mean of four measurements obtained at 45° intervals on one cross-section at mid-length, each measurement being made to within 0,5 %.

Record the calculated mean inside diameter d_{ia}, d_{ib} and d_{ic} for each test piece **a**, **b** and **c**, respectively.

Calculate the average value d_i of these three values using the following equation:

$$d_i = \frac{d_{ia} + d_{ib} + d_{ic}}{3}$$

5.4 Age of test pieces

At the start of the test, the age of the test pieces shall be 21 days ± 2 days.

NOTE 1 For the determination of the creep ratio of pipes with ages outside these limits, see annex B.

6 Conditioning

Condition the test pieces in air at the test temperature (see 7.1) for at least 24 h immediately prior to testing.

7 Procedure

7.1 Unless otherwise specified in the referring standard, carry out the test procedure at 23 °C ± 2 °C or, in countries where 27 °C is used as the standard laboratory temperature, at 27 °C ± 2 °C.

In cases of dispute, 23 °C ± 2 °C shall be used.

7.2 If it can be determined in which position the test piece has the lowest ring stiffness, place the first test piece **a** in this position in the compressive-testing machine.

Otherwise, place the first test piece in such a way that the marking line is in contact with the upper plate.

Rotate the two others **b** and **c** by 120° and 240°, respectively, in relation to the first test piece when placing them in the testing machine.

7.3 For each test piece, attach the deflection gauge and check the angular position of the test piece with respect to the upper plate.

7.4 Lower the upper plate until it touches the upper part of the test piece.

Apply one of the following pre-load forces F_0, as applicable, taking into account the mass of the upper plate:

a) for pipes with d_i less than or equal to 0,1 m, F_0 shall be 7,5 N;

b) for pipes with d_i larger than 0,1 m, calculate F_0 in newtons, using the following equation and rounding the result to the next highest whole number:

$$F_0 = 75 d_i$$

where d_i is the numerical value of d_i measured in metres.

7.5 Within 5 min of applying the pre-load force, set the deflection gauge to zero and start applying a steadily increasing compressive force such that, between 20 s and 30 s after starting, a loading force F is reached. This force F shall be chosen such that after 360 s (6 min) the test piece shows a deflection ratio of 1,5 % ± 0,2 %, i.e.

$$\frac{\delta}{d_i} = 0{,}015 \pm 0{,}002$$

At the moment when this full loading force F is reached, start the timer.

7.6 Determine the initial deflection y_0 6 min after the application of the full load. Then determine the deflection 1 h, 4 h, 24 h, 168 h, 336 h, 504 h, 600 h, 696 h, 840 h, 1 008 h after application of the full load.

If the value of y_0 is outside the limits specified in 7.5, interrupt the test, recondition the test piece for at least one hour and restart the test at 7.3.

NOTE 2 A series of eleven deflection values is obtained for each test piece.

Where it is not possible to read the deflection gauges at the appropriate times between 500 h and 1 008 h, if is permissible to deviate by ± 24 h, providing the actual measurement time is used in preparing the plots described in clause 8.

EXAMPLE

Instead of taking the reading at 840 h, the deflection is read after 862 h. In this case the value of 862 h is used in the regression analysis.

NOTE 3 When the stiffness test is started on a Monday or Thursday, weekends do not interfere with the test.

8 Determination of creep ratio

8.1 Calculation

For each of the three test pieces, plot the deflection in metres against the logarithm of time in hours on a semi-logarithmic coordinate system (see figure 4) and determine by linear regression the equation of the straight line

$$Y_t = B + M \lg t$$

through all eleven points, through the last ten points, through the last nine points, ..., and through the last five points (see table 2), where the constants B and M and the correlation coefficient R are determined using the following equations (i.e. using the method of least squares):

$$M = \frac{N\sum x_i y_i - \sum y_i \sum x_i}{N\sum x_i^2 - \left(\sum x_i\right)^2}$$

$$B = \frac{\sum y_i - M\sum x_i}{N}$$

$$R = \left[\frac{M\left(N\sum x_i y_i - \sum x_i \sum y_i\right)}{N\sum y_i^2 - \left(\sum y_i\right)^2}\right]^{1/2}$$

B being the theoretical deflection, in millimetres, at $t = 1$ h,

M being the gradient,

N being the number of points on the deflection curve used for the linear-regression analysis,

R being the correlation coefficient (if R has a value between 0,99 and 1,00, it is assumed that the plotted points lie on a straight line),

t_i being the time at the ith point, given by the equation

$$x_i = \lg t_i$$

y_i being the measured total deflection at time t_i.

For each of the seven equations $Y_t = B + M \lg t$ obtained for a given test piece, calculate the extrapolated two-year deflection Y_2, in millimetres (t = 2 years = 17 520 h) (see table 2).

Choose as the value for the two-year deflection Y_2 (for calculation of the creep ratio of the test piece) the highest calculated value of Y_2 that has a correlation coefficient R of 0,999 or that has the highest value of R between 0,990 and 0,999.

If the highest value of R is less than 0,990, see 8.2.

Having determined Y_2, calculate the creep ratio for each of the three test pieces using the following equations:

$$\gamma_a = \frac{Y_{2a}\left(0{,}018\,6 + 0{,}025\,\frac{y_{0a}}{d_i}\right)}{y_{0a}\left(0{,}018\,6 + 0{,}025\,\frac{Y_{2a}}{d_i}\right)}$$

$$\gamma_b = \frac{Y_{2b}\left(0{,}018\,6 + 0{,}025\,\frac{y_{0b}}{d_i}\right)}{y_{0b}\left(0{,}018\,6 + 0{,}025\,\frac{Y_{2b}}{d_i}\right)}$$

$$\gamma_c = \frac{Y_{2c}\left(0{,}018\,6 + 0{,}025\,\frac{y_{0c}}{d_i}\right)}{y_{0c}\left(0{,}018\,6 + 0{,}025\,\frac{Y_{2c}}{d_i}\right)}$$

Report the creep ratio of the pipe as the arithmetic mean of the three values obtained above, calculated using the following equation:

$$\gamma = \frac{\gamma_a + \gamma_b + \gamma_c}{3}$$

8.2 Example of a creep calculation

A typical set of deflection/time data for one test piece is given in table 2 together with the subsequently calculated values of M, B, R and Y_2 for different ranges of points as given in column four which indicates which points have been included in the regression analysis.

The resulting plot is given in figure 4 where, in accordance with clause 8, Y_2 is based on the set of not less than five points for which R has the highest value above 0,990.

Table 2 — Typical set of deflection/time data for one test piece

Point number	Time t h	Y_t mm	Range of points	M	B	R	Y_2
1	0,1	6,529	1 to 11	0,505	6,683	0,950	8,830
2	1	6,649	2 to 11	0,612	6,424	0,967	9,023
3	4	6,780	3 to 11	0,710	6,170	0,972	9,185
4	24	7,019	4 to 11	0,888	5,695	0,982	9,463
5	168	7,534	5 to 11	1,196	4,842	0,996	9,921
6	336	7,849	6 to 11	1,311	4,517	0,996	10,081
7	504	8,049	7 to 11	1,422	4,195	0,998	10,232
8	600	8,134					
9	696	8,234					
10	864	8,384					
11	1 008	8,464					

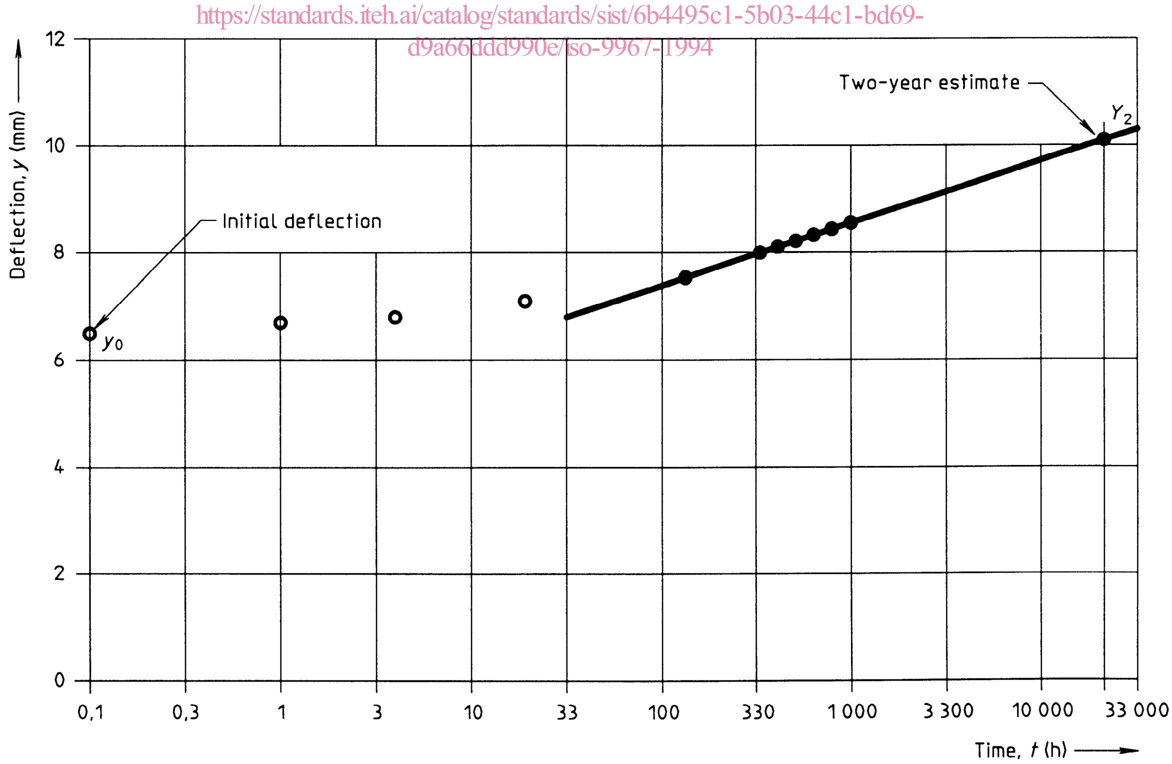


Figure 4 — Deflection/time plot for one test piece