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NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA

ICS 83.120

CCS Q 23

GB/T 43117-2023 / ISO 10468:2018

**Glass-reinforced Thermosetting Plastics (GRP) Pipes -
Determination of the Ring Creep Properties under Wet or
Dry Conditions**

玻璃纤维增强热固性塑料（GRP）管湿态或干态条件下环蠕变性能
的测定

(ISO 10468:2018, IDT)

Issued on: September 7, 2023

Implemented on: April 1, 2024

Issued by: State Administration for Market Regulation;

Standardization Administration of the People's Republic of China.

Table of Contents

Foreword.....	3
1 Scope.....	4
2 Normative References.....	4
3 Terms and Definitions.....	4
4 Principle	8
5 Test Device.....	8
6 Specimen.....	10
7 Quantity of Specimens.....	11
8 Measurement of Specimen Dimensions.....	11
9 Specimen Conditioning.....	11
10 Test Steps	11
11 Calculation	12
12 Test Report.....	13

Glass-reinforced Thermosetting Plastics (GRP) Pipes - Determination of the Ring Creep Properties under Wet or Dry Conditions

1 Scope

This document describes the test method for the ring creep properties under wet (completely immersed in water) or dry conditions of glass-reinforced thermosetting plastics (GRP) pipes. Creep properties include creep factor and long-term creep stiffness.

This document is applicable to the determination of long-term creep properties under simulated conditions of use through testing and evaluation, and control of raw material consistency under dry conditions, or through testing under wet conditions.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

ISO 3216 Plastics Piping Systems - Plastics Components - Determination of Dimensions

NOTE: GB/T 8806-2008 Plastics Piping Systems - Plastics Components - Determination of Dimensions (ISO 3126:2005, IDT)

ISO 7685 Glass-reinforced Thermosetting Plastics (GRP) Pipes - Determination of Initial Ring Stiffness

ISO 10928 Plastics Piping Systems - Glass-reinforced Thermosetting Plastics (GRP) Pipes and Fittings - Methods for Regression Analysis and Their Use

3 Terms and Definitions

The following terms and definitions are applicable to this document.

3.1 vertical compressive force

F

A vertical force exerted on a horizontally placed pipe, which leads to deformation of the pipe.

Where,

e ---the pipe wall thickness, expressed in (m);

y_1 ---the vertical deflection at position 1, expressed in (m);

d_m ---the mean diameter (3.3), expressed in (m).

4 Principle

Through a loading plate or a supporting beam, exert a vertical compressive force on the entire length of a horizontally placed pipe ring specimen of a certain length, so that the pipe ring reaches the specified strain level [see Formula (8) for strain calculation].

Maintain the vertical compressive force of the pipe ring constant and regularly measure the vertical deflection. Through the extrapolation method, estimate the long-term specific ring creep stiffness. When determining the specific ring creep under wet conditions, the pipe ring shall be immersed in water of a certain temperature. In accordance with the long-term specific ring creep stiffness and the specific ring stiffness of the same specimen at 0.1 h, determine the creep factor. The measurement result is the average value of two specimens.

The following test parameter values are specified by relevant standards:

- a) Data extrapolation time (see 3.6 and 11.1);
- b) Test temperature (see 5.3 and 10.1);
- c) Specimen length (see Chapter 6);
- d) If applicable, the parameters of state conditioning: temperature, humidity and duration (see Chapter 9);
- e) Limitation of the duration of the specimen under load (see 10.6);
- f) The strain level used for testing;
- g) Test conditions: dry conditions or wet conditions.

5 Test Device

5.1 Compression Loading Machine

The loading machine shall have a force application system, which can apply load to two parallel action surfaces in accordance with the stipulations of 5.2, so that a pipe specimen horizontally immersed in water is subject to vertical compression without vibration, and can maintain a constant vertical compressive force within the test time in accordance with the stipulations of 10.6.

The force measurement accuracy of the loading machine is $\pm 1\%$.

The loading machine shall ensure that the vertical compressive force is not affected by friction and buoyancy during the creep test under wet conditions.

5.2 Action Surface of Force

5.2.1 Overall design

Loading plates or supporting beams can be chosen to load the specimen, but it needs to be indicated in the test report. During the determination of initial specific ring stiffness and long-term specific ring stiffness, the same loading mode shall be adopted (use loading plates and supporting beams, or a combination of loading plates and supporting beams above and below).

The action surface shall be a pair of loading plates that comply with the requirements of 5.2.2 or a pair of supporting beams that comply with the requirements of 5.2.3, or consist of a loading plate and a supporting beam. The action surface shall be perpendicular to the vertical compressive force F , which is at the center of the action surface, as shown in Figure 1. The two surfaces in contact with the specimen shall be flat, smooth and parallel to each other.

5.2.2 Loading plate

The width of the loading plate is at least 100 mm, and the length is at least equal to the length of the specimen. In order to ensure that no significant bending or deformation occurs during the test, the loading plate shall have sufficient stiffness.

5.2.3 Supporting beam

The width of the supporting beam is 15 mm ~ 55 mm, and the length is at least equal to the length of the specimen. Meanwhile, there shall be no sharp edges. In order to ensure that no significant bending or deformation occurs during the test, the supporting beam shall have sufficient stiffness. The supporting beam shall be constructed and supported, so that no other surface of the supporting beam structure comes into contact with the specimen during the test.

5.3 Water Reservoir

When carrying out the test under wet conditions, the water reservoir shall have a sufficiently large volume, so as to ensure that the specimen subject to the vertical compressive force specified in Chapter 6 is completely immersed in water. The temperature of the water shall be kept constant, and the pH shall be 7 ± 2 .

The water level shall be kept constant, so as to avoid significant fluctuations in the vertical compressive force, to which, the specimen is subject during the test.

5.4 Measuring Device

The measuring device shall comply with the following requirements:

4---constant load;

9---action surface of supporting beam.

5---action direction of vertical compressive force F ;

NOTE 1: for the wet-condition creep test, throughout the test, the specimen is completely immersed in water, and the deflection measuring device, constant load device, and the loading plate and supporting beam above the specimen are all allowed to be placed above the water surface.

NOTE 2: the test device shown in the Figure includes a water reservoir for the wet-condition creep test. The dry-condition creep test is the same as the wet-condition creep test, except for the water and water reservoir.

Figure 1 -- Typical Creep Test Device

The ends of the specimen shall be flat. During cutting, it shall be ensured that the cutting direction is perpendicular to the axial direction of the pipeline. The cut surfaces at both ends of the specimen can be edge-sealed.

On the outside or inside of the specimen, along the length direction, at an interval of 60° around its circumference, draw three pairs of reference lines.

7 Quantity of Specimens

2 specimens in each group.

8 Measurement of Specimen Dimensions

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

9 Specimen Conditioning

If applicable, conduct specimen conditioning in accordance with the requirements of relevant standards.

10 Test Steps

10.1 The test temperature of each specimen shall satisfy the stipulations of relevant standards.

10.2 In accordance with the stipulations of ISO 7685, adopt the constant load method to carry out the test and record the initial specific ring stiffness S_0 of the specimen. Use the S_0 measurement value at a pair of reference lines of the designated “position 1” to estimate the compressive force required to compress the specimen to a specific vertical deflection within 3

min. The vertical deflection value of the specimen shall satisfy that the calculated strain at “position 1” is between 0.13% ~ 0.17%, unless it is otherwise specified in relevant standards.

10.3 Place the specimen in the test device, contact the upper and lower loading plates or supporting beams at “position 1” determined by the two relative reference lines specified in 10.2, and vertically align. Ensure full contact between the specimen and each loading plate or supporting beam, and that the loading plate or supporting beam does not tilt sideways. Under wet conditions, the test device needs to be placed in a water reservoir.

10.4 If the test is carried out under wet conditions, fill the water reservoir with water, until the specimen is completely immersed in water.

10.5 When the specimen is completely immersed in water (if applicable), in accordance with 10.2, estimate and apply a vertical compressive force F . When necessary, the weight of the upper loading plate or supporting beam shall be included. Within 3 min, load to the predetermined vertical deflection, and record the actual vertical compressive force value and the corresponding vertical deflection.

10.6 Maintain a constant vertical compressive force throughout the test. Start from no more than 1 h after loading, and continue, until reaching the specified time (for the test of creep modulus under wet conditions, the test time is above 10,000 h), measure and record the deflection of the specimen at approximately equal $\lg$ (hours) intervals. The measurement accuracy shall be within 2% of the initial deflection value, and the recording time interval shall be the time corresponding to 10 approximately equal fractions within the $\lg$ (hours) integer interval.

11 Calculation

11.1 Extrapolation of Deflection Data

If it is required in relevant standards, for each specimen, use the test data obtained from 10.6 to draw a function curve related to $\lg$ (deflection) and $\lg$ (hours).

For each specimen, in accordance with the measured deflection value and the corresponding test data of the test time between 1 h and more than 10,000 h, use Formula (9) to calculate the specific ring creep stiffness at the corresponding test time of each specimen at position 1. In addition, in accordance with ISO 10928, analyze the test data of specific ring creep stiffness and corresponding test time.

$$S_{x,1,\text{creep}} = \frac{fF}{Ly_{x,1}} \dots\dots\dots (9)$$

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

Where,

$S_{x,1,\text{creep}}$ ---when the time is x hour or x year, the specific ring creep stiffness at position 1,

expressed in (N/m²);

f ---the deflection coefficient, which is calculated from Formula (10) [refer to Formula (7)];

F ---the vertical compressive force, expressed in (N);

L ---the average length of the specimen, expressed in (m);

$y_{x,1}$ ---when the time is x hour or x year, the vertical deflection value generated by the constant load at position 1 in 10.6 after x hour or x year, expressed in (m).

11.2 Calculation of Long-term Specific Ring Creep Stiffness at Position 1

Use the analysis results in 11.1, calculate and report the long-term specific ring creep stiffness $S_{x,1, \text{creep}}$ at position 1 at x hour or x year (refer to the stipulations of relevant standards).

11.3 Calculation of Creep Factor

For each specimen, use Formula (6) to calculate the creep factor $\alpha_{x, \text{creep}}$.

NOTE: $S_{0,1}$ is the specific ring stiffness (see Formula 6) at position 1 when the time is 0.1 h. The value measured during the test significantly fluctuates, which will affect the calculation results of the long-term creep factor. Hence, $S_{0,1}$ is usually calculated from 11.2.

In accordance with this document, the measurement result of creep factor shall be the average value of the measured $\alpha_{x, \text{creep}}$ of two specimens.

12 Test Report

The test report shall include the following contents:

- a) Serial No. of this document and related standards;
- b) All information about the pipeline being tested;
- c) Quantity of specimens;
- d) Dimensions of each specimen;
- e) Specific location of each specimen in the pipeline;
- f) The initial specific ring stiffness S_0 of each specimen and the specific ring stiffness $S_{0,1}$ at position 1 when the time is 0.1 h;
- g) The vertical compressive force F , initial deflection value and initial strain of each specimen at 3 min;
- h) If used, details of state conditioning (see Chapter 9);

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