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Glass reinforced thermosetting plastic (GRP) pipes — Determination of initial specific ring stiffness using segment test species cut from a pipe

Tubes en plastique thermodurcissables renforcés de verre (PRV) — Détermination de la rigidité annulaire spécifique initiale et de la résistance à la déflexion annulaire initiale en utilisant des éprouvettes segmentaires découpées dans un tube

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Foreword

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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 documents 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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, SC 6, *Reinforced plastics pipes and fittings for all applications*.

Introduction

This document develops an alternative to the testing of full pipe rings to measure initial specific ring stiffness (ISO 7685). The goal was to use ring segments which ideally would have led to the use of smaller and more easily handled test specimens and standard testing machines. Much work was done on developing equipment for testing ring segments and on the analysis of loading conditions and calculation procedures and conducting testing programs.

There was neither sufficient nor uniform correlation of segment testing results to standard ring testing results to allow the use of segment testing as an alternative stiffness test procedure. There were indications that correlation was perhaps diameter (DN), stiffness class (SN) and pressure class (PN), as well as specimen width, dependent. As initial ring stiffness (SN) is a key classification parameter for GRP pipes this resulted in the segment test being not accepted as a viable alternative stiffness testing procedure.

This document presents the last draft of the segment test method. It was agreed to issue this last draft as a Technical Specification so that the work done would not be lost and perhaps will allow interested parties to continue to develop the analysis of loading conditions, equipment development and calculation procedures. It may also prove useful as a research tool.

Glass reinforced thermosetting plastic (GRP) pipes — Determination of initial specific ring stiffness using segment test species cut from a pipe

1 Scope

This document specifies a method for determining the initial specific ring stiffness of pipes having a nominal size of DN 2000 or larger, using segment test pieces cut from a glass-reinforced thermosetting plastics (GRP) pipe.

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, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of initial specific ring stiffness*

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
compressive load
F
load applied to a pipe to cause a diametric deflection

Note 1 to entry: Compressive load is expressed in newtons (N).

3.2
load applied to 79 ° segmental test piece
F_{79}
load applied to 79 ° segmental test piece to cause deflection

Note 1 to entry: Load applied to 79 ° segmental test piece is expressed in newtons (N).

3.3
deflection coefficient applied to 79 ° segmental test piece
ξ
coefficient given by Formula (1):

$$\xi = \left\{1860 + \left(2500 \times y_s / d_m\right)\right\} \times 10^{-5} \quad (1)$$

where

y_s is the vertical deflection of the pipe ring derived from the 79 ° pipe segment (see 3.7);

d_m is the mean diameter of the pipe ring (see 3.8).

Note 1 to entry: Deflection coefficient applied to 79 ° segmental test piece is a dimensionless number.

3.4
vertical deflection
y
vertical change in diameter of a pipe in a horizontal position in response to a vertical *compressive load* (3.1)

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

3.5
relative vertical deflection
y/d_m
ratio of the *vertical deflection* (3.4) of a pipe, *y*, to its *mean diameter*, d_m (3.8)

Note 1 to entry: Relative vertical deflection when multiplied by 100 is expressed in percent (%). Otherwise it is a dimensionless number.

3.6
derived vertical deflection of pipe segment
y_d
vertical deflection of the pipe segment, using Formula (2), which is derived by finite element analysis of a pipe ring and which results in the same loading conditions as if the pipe segment were part of a pipe ring deflected by the vertical deflection *y*

$$y_d = y \times \alpha_{79} \tag{2}$$

where α_{79} is the conversion factor for 79 ° segment test piece determined by finite element analysis (see Table 1).

Note 1 to entry: Derived vertical deflection is expressed in metres (m).

3.7
vertical deflection of pipe ring y_s derived from 79 ° pipe segment test
ratio of the vertical deflection of a pipe ring, to the derived vertical deflection of a 79 ° pipe segment taken from the same pipe, when the same deflection force is applied to each unit is given by the following formula:

$$y_s = 3{,}469\ y_d \tag{3}$$

where

y_s is the vertical deflection of pipe ring;

y_d is the derived vertical deflection of 79° segment.

3.8
mean diameter
d_m
diameter of the circle corresponding with the middle of the pipe wall cross-section

It is given by either Formula (4) or (5):

$$d_m = d_i + e \tag{4}$$

$$d_m = d_e - e \tag{5}$$

where

d_i is the average of the measured internal diameters (see 6.3.3);

d_e is the average of the measured external diameters (see 6.3.3);

e is the average of the measured wall thicknesses of the pipe (see 6.3.2).

Note 1 to entry: Mean diameter is expressed in metres (m) when the wall thickness and diameters are measured in metres (m).

3.9
specific ring stiffness
S
physical characteristic of the pipe, which is a measure of the resistance to ring deflection under external load

Note 1 to entry: Specific ring stiffness is determined by testing and is defined, in newtons per square metre (N/m^2), by Formula (6):

$$S = EI / d_m^3 \tag{6}$$

where

E is the apparent modulus of elasticity as determined in the ring stiffness test, expressed in newtons per square metre (N/m^2);

d_m is the *mean diameter* (3.8) of the test piece, in metres;

I is the second moment of area in the longitudinal direction per metre length, expressed in metres to the fourth power per metre, i.e.

$$I = e^3 / 12 \tag{7}$$

where e is the wall thickness of the test piece, in metres.

3.10
initial specific ring stiffness
S_0
initial value of S obtained by testing in accordance with this document.

Note 1 to entry: Initial specific ring stiffness is expressed in newtons per square metre (N/m^2).

3.13
average width of 79 ° segmental test piece
b
average of three measurements taken at specified locations on the segment test piece (see 6.1 and 6.3.1)

Note 1 to entry: Average width is expressed in metres (m).

3.14
load correction factor
β
factor applied to the measured deflection load F_{79} applied to a 79° segment during test

$$\beta = (d_m - e) / d_m \tag{8}$$

where

d_m is the mean diameter (see 3.8) of the test piece, in metres;

e is the wall thickness of the test piece, in metres

Note 1 to entry: This compensates for the supports being placed at segment the edges instead of centre of segment edges

4 Principle

4.1 Overview

To overcome problems with the size of the testing equipment and test pieces, when using full rings of large diameter pipes to determine the initial stiffness, the test procedures described in this document have been developed using 79 ° segments taken from full rings of pipe. Using formulae given in the document, the required deflection, to be applied to the segment, is determined which ensures that the test piece will be subject to the same level of strain as a full ring test piece when testing in accordance with ISO 7685.

4.2 Principle of test procedures to determine initial specific ring stiffness

A segment of pipe is loaded across its width to deflect it vertically. Two ways are given for doing this: method A (constant load) and method B (constant deflection), either of which can be used.

4.2.1 Method A

A load is applied to a segment test piece to give a deflection equal to the segment's deflection when considered as part of a full ring which is deflected to (3 ± 0,5) % in accordance with ISO 7685. The load is kept constant for a specified period of time and the final deflection is determined at the end of this period.

4.2.2 Method B

A load is applied to a segment test piece to give a deflection equal to the segment's deflection when considered as part of a full ring which is deflected to (3 ± 0,5) % in accordance with ISO 7685. The deflection is kept constant for a specified period of time and at the end of this period the final load being applied is determined.

It is assumed that the following test parameters specified in this Test Method will be either accepted or restated in any International Standard referring to this Test Method:

a) the method to be used (A or B);

b) the width of the test pieces (see 6.1);

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

d) if applicable, the details of conditioning of the test pieces (see Clause 7).

5 Apparatus

5.1 Compressive-loading machine, comprising a system capable of applying, without shock, a compressive force, F, (suitable for the applicable test method described in Clause 4) at a controlled rate through a load application surface conforming to 5.2 so that a horizontally orientated segmental test piece conforming to Clause 6 can be deflected vertically. The accuracy of loading shall be within ± 1 % of the maximum indicated load.

5.2 Load application surface — General arrangement

The surface shall be provided by a plate (see 5.2.1), or a beam bar (see 5.2.2), with their major axis perpendicular to and centred on the direction of application of the load, *F,* by the compressive-loading machine, as shown in Figures 1 and 2. The surfaces in contact with the test piece shall be flat, smooth, clean and parallel. A plate or beam bar shall have a length at least equal to the width of the test piece (see Clause 6) and a thickness such that visible deformation does not occur during the test.

5.2.1 Plate, shall have a width of at least 100 mm.

5.2.2 Beam bar, shall have rounded edges, a flat face (see Figure 1) without sharp edges and a width of 50 mm ± 5 mm. The beam bars shall be designed and supported such that no other surface of the beam bar structure comes into contact with the test piece during the test.

5.3 Dimension-measuring instruments

Capable of determining:

— the necessary dimensions (length, width, diameter, wall thickness) to an accuracy of within ± 0,1 mm;

— the deflection of the test piece in the vertical direction to an accuracy of within ± 1,0 % of the maximum value.

5.4 Temperature-measuring instrument

If applicable, capable of verifying conformity to the specified test temperature (see 8.1).