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Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure

Systèmes de canalisations en plastiques — Tubes en plastiques thermodurcissables renforcés de verre (PRV) — Détermination du temps mis jusqu'à la défaillance sous une pression interne constante

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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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 06, *Reinforced plastics pipes and fittings for all applications*.

This second edition cancels and replaces the first edition (ISO 7509:2000), which has been technically revised.

Introduction

This International Standard describes a method for determining the long-term resistance to internal pressure of glass-reinforced thermosetting plastics (GRP) pipes.

It is a method which uses the following conditions:

— water as the reference liquid inside the test piece;

— water or air, as the environment outside the test piece.

The method can be used for tests at different temperatures. It should be noted that, for a given temperature, the results obtained can differ depending on the end loading conditions and whether the external environment is water or air.

The method described in this International Standard differs from those in some other similar standards in the following details:

— the failure criteria and the detection of failure;

— the strain in the longitudinal and circumferential directions can be measured during the test;

— the test pressure is maintained constant.

This method can be used to obtain data to establish internal pressure versus time-to-failure relationships at different temperatures. The procedures for establishing the relationships are not within the scope of this International Standard. For such purposes, attention is drawn to ISO 10928.

Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure

1 Scope

This International Standard specifies a method for determining the time-to-failure of glass-reinforced thermosetting plastics (GRP) pipes under internal hydrostatic pressure at a specified temperature. The external environment can be air or water.

NOTE For other internal or external environments, the referring standard is to specify any additional requirement.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 10928, *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
failure
occurrence of bursting, leaking, or weeping

Note 1 to entry: See 9.1.

3.2
bursting
failure by rupture of the pipe wall with immediate loss of test liquid and drop of pressure

Note 1 to entry: See 9.1 and 9.2.1.

3.3
leaking
failure by visible loss of the pressurizing liquid through the pipe wall to an extent detectable visually and/or by a continuous drop in pressure

Note 1 to entry: See 9.1 and 9.2.1

3.4
weeping
failure by passage of the pressurizing liquid through the pipe wall to an extent detectable visually and/or electronically

Note 1 to entry: See 9.1 and 9.2.2.

4 Principle

A cut length of pipe at the required temperature is subjected to a specified internal hydrostatic pressure to cause a state of stress in the pipe wall, which depends upon the loading conditions (i.e. with or without the effects of end thrust being carried by the pipe wall). The results of tests at different end loading conditions will be different even for the same pipe. Water or air may be used as the environment outside of the test piece.

The test samples are held at the test pressure until failure occurs. Typically, the time to failure is longer at lower pressures (stresses).

In general, a series of tests are conducted over various failure times and the results obtained are analysed in accordance with ISO 10928 to establish a long term value. The number of tests required, the appropriate time intervals, and the time at which a value is established (time to failure) are given in the referring standard.

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

a) whether or not the test piece is to be loaded by the hydrostatic end thrust while under pressure (5.2);

b) free length, *L*, of the test piece (see 6.2);

c) number of test pieces (see 6.1);

d) test temperature and its tolerance (see 8.1);

e) if and what strain measurements are required (see 8.2);

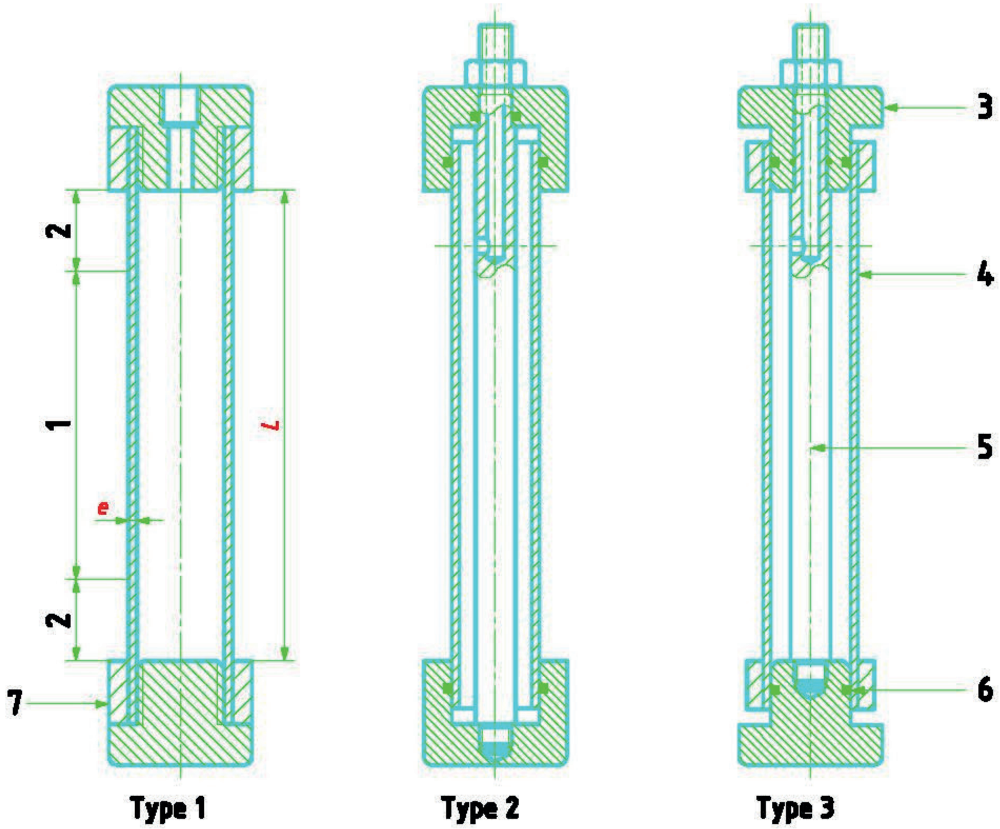
f) external environmental fluid, i.e. water or air (see 8.3) or other environment (see Note in Clause 1);

g) internal environmental fluid, if not water or a test liquid for the purposes of 5.7 and 9.2.2 (see Note in Clause 1).

5 Apparatus

5.1 Dimensional measurement devices, for determining length, diameter, and wall thickness with an accuracy of within ±1,0 %.

5.2 End sealing devices, for the test piece, capable of inducing the specified state of stress, i.e. with or without hydrostatic end thrust (see Figure 1). The end sealing concepts shown in Figure 1 are only typical and other configurations are possible.



Key

1 valid failure zone

2 end fixture influence zone, equal to $3{,}3 \times ([\mathrm{DN}] \times e)^{0{,}5}$

3 end cap

4 test specimen

5 tie rod to carry end thrust

6 elastomeric seal

7 end seal device

e wall thickness

L free length between end fixtures

Type 1 testing with end thrust

Type 2 testing without end thrust, external seals

Type 3 testing without end thrust, internal seals

Figure 1 — Typical arrangements for pressure testing of pipes

5.3 Test piece support(s), as necessary to minimize deformation of the test piece due to its own weight. Such support(s) shall not constrain the test piece circumferentially or longitudinally.

5.4 Container for water, if tested with water as the external environment (see 8.3), equipped so that the specified temperature can be maintained uniformly throughout the liquid.

NOTE This can require circulation.

5.5 Pressurizing system, capable of applying the pressure to the liquid in the test piece in such a way as to avoid entrapment of air. The system shall be capable of maintaining the pressure within the limits detailed in 8.5 for the duration of the test.

The pressure should, preferably, be applied individually to each test piece. However, the use of equipment enabling the pressure to be applied simultaneously to several test pieces is also permitted if there is no danger of interference when failure occurs.

If the tests are carried out at a specified stress, the dimensions of the various test pieces should be similar.

It is recommended that an automatic system be used which adjusts the pressure to keep it within the specified limits.

5.6 Pressure measuring device, having an accuracy within ±1,0 % of the test pressure.

5.7 Electrical resistance meter and associated circuit (optional, see 9.1), capable of detecting a change in electrical resistance to a level of 3 MΩ or less (see 9.2.2) between a sufficiently conductive test liquid and a conductive layer.

5.8 Strain measuring device(s) (optional, see 8.3), capable of measuring the required strain to an accuracy of within ±2 %.

6 Test pieces

6.1 Number

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

6.2 Free length

Each test piece shall comprise of a full section of the pipe, the free length (*L*) which, between the sealing devices, shall be as specified in the referring standard.

6.3 Cutting

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

7 Conditioning

Unless otherwise specified by the referring standard, store the test piece(s) at the test temperature (see 8.1) for 24 h prior to testing.

8 Procedure

8.1 Conduct the following procedures at the temperature and tolerance specified in the referring standard.

8.2 In accordance with ISO 3126, measure the pipe diameter, wall thickness, and test sample length.

8.3 If strain measurements are required, attach strain gauges and use equipment conforming to 5.8.

8.4 Attach the end-sealing devices (5.2) to the test piece (see Clause 6) and fill the assembly completely with water or the test liquid (5.7). Attach the test piece to the pressurizing system, avoiding entrapment of air.

If testing with water as the external environment, install the test piece in the container (5.4) so that it is totally surrounded with water.

8.5 Raise the pressure inside the test piece to the desired level within 5 min (5.5). Maintain the pressure until failure. Record the test period to an accuracy of ±2 % of the duration of the test period (in hours) or 24 h, whichever is the shorter.

NOTE For some nominal sizes greater than DN 500, the duration of the test will, for practical reasons, need to be increased.

8.6 In case of an interruption in testing due to unforeseen circumstances, such as power failure, the test may be continued if the duration of the interruption is less than 100 h. The length of the time of interruption(s) shall be deducted from the total running time of the test and shall be noted in the test report.

9 Detection of failure

9.1 General

The test piece shall be considered to have failed when bursting (3.2), leaking (3.3), or weeping (3.4) is observed. Bursting or leaking can be detected visually or by loss of test liquid (see 9.2.1). Weeping can be detected visually or physically by measuring the electrical resistance (see 9.2.2).

NOTE Weeping can be determined only when the test is carried out in air.

Because of the very high stresses (strains) generated by the extreme pressures used to develop short-term data points, the discontinuity effects of the end closures can significantly influence the apparent times to failure. If the failure can be clearly identified as initiating from end fixture influence, the result of the test may be discarded if the failure occurs outside the valid failure zone, i.e. within a distance from an end sealing device, given in Formula (1):

$$3{,}3 \times \left([\mathrm{DN}] \times e \right)^{0{,}5} \quad (1)$$

where

[DN] is the nominal size, expressed in millimetres;

e is the wall thickness, in millimetres.

Where feasible (i.e. where failure is by leaking or weeping), failures outside the valid zone may be repaired, as needed, and the test continued. Any such continuation shall be noted in the test report.

9.2 Detection methods

9.2.1 Loss of test liquid

A visible loss of the test liquid through the pipe wall shall be considered as failure (see 9.1).

9.2.2 Drop in electrical resistance

If applicable, a failure shall be considered to have occurred when the electrical resistance between the test liquid and a conductive layer around the external circumference of the test piece falls to less than or equal to 3 MΩ (see Annex A).

NOTE Care is to be taken to ensure that the electrical conductivity of the test liquid and the electrical resistivity of the pipe are high enough.

10 Test report

The test report shall include the following information:

a) reference to this International Standard (i.e. ISO 7509) and the referring standard;

b) full identification of the pipes tested;

c) dimensions of each test piece;

d) number of test pieces;

e) operating limits of the pressurizing system (5.5);

f) measured strains, if required;

g) range of temperature during testing;

h) external test environment (5.4);

i) state of stress (5.2);

j) length of the valid failure zone (see 9.1);

k) type of end sealing device (see Figure 1);

l) details of the test piece support, if used (5.3);

m) test pressure for each test piece (see 8.4);

n) either the time to failure or the duration of test (see 8.4) for each test piece;

o) image (i.e. sketch, photograph, etc.) showing the nature and position of failure points for each test piece;

p) failure mode for each test piece (see 9.1);

q) any data points eliminated due to failures outside the valid failure zone;

r) observations made during and after the test;

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

t) date of test or dates between which the test was conducted.

Annex A
(informative)

Electronic leak/weep detection

The use of an electronic device to measure the electrical resistance between the test fluid and a conductive material wrapped around the circumference of the test specimen has been used for many years to assist in the detection of weeping or leaking failures, typically for filament wound pipes. This use of electronic detection was first recognized in ASTM D 2143 in determining the cyclic pressure strength of thin wall filament wound GRP pipes in the 1960s.

The conductive material wrapped around the test specimen is typically a metallic foil or mesh placed around the sample in the valid failure zone, i.e. away from the end closures. Measurement of the resistance between the test fluid and the conductive material can be indicative of failure or pending failure.

The resistance trigger for insipient failure will depend on the test fluid. Historically, for test fluids containing sodium chloride, a resistance in the range of 10 MΩ to 20 MΩ was considered as failure onset. For municipal water as the test fluid, failure is frequently taken as when the first drop of fluid has passed through the pipe wall.

In recent years, the testing of GRP-UP pipes has found a resistance of 3 MΩ to be indicative of pending failure by either weeping or leaking. Some testers use electronic monitoring to identify possible pending failure and the need for more frequent visual observation. The use of such detection methods is particularly useful for longer time periods of test where direct observation is frequently not practical.

When testing at elevated temperatures, the use of electronic detection can be particularly helpful as the almost simultaneous appearance of a water droplet on the pipe surface and the evaporation of the droplet makes visual detection difficult, if not impractical.

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