
**Glass-reinforced thermosetting
plastics (GRP) pipes and fittings —
Determination of the resistance to
chemical attack for the inside of a
section in a deflected condition**

*Tubes et raccords en plastiques thermodurcissables renforcés de verre
(PRV) — Détermination de la résistance à une attaque chimique à
l'intérieur d'un tronçon de tube soumis à déflexion*

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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.

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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of 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 www.iso.org/iso/foreword.html.

This document 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 fourth edition cancels and replaces the third edition (ISO 10952:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the tolerances for the dimensional measuring devices in [6.2](#) have been modified;
- the measurement of the mean wall thickness in [8.2](#) and the mean diameter in [8.3](#) have been specified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of the resistance to chemical attack for the inside of a section in a deflected condition

1 Scope

This document specifies a method for determining the chemical resistance properties of glass-reinforced thermosetting plastics (GRP) pipes and fittings in a deflected condition for nominal sizes DN 100 and larger.

In conjunction with ISO 10928, this document provides a method for evaluating the effect of a chemical environment on the interior of a pipe or fitting after a specified period of time. Test conditions and requirements are specified in the referring International Standard. ISO 23856 references this document.

NOTE It has been found that the effect of chemical environments can be accelerated by strain induced from deflection; hence, this type of effect is frequently referred to as strain corrosion.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

mean diameter

d_m

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

Note 1 to entry: The mean diameter is given by either of the following formulae:

$$d_m = d_i + e_m$$

$$d_m = d_e - e_m$$

where

d_e is the external diameter of the pipe;

d_i is the internal diameter of the pipe;

e_m is the mean wall thickness of the pipe at the bottom.

Note 2 to entry: The mean diameter and the dimensions used to calculate it are expressed in millimetres.

3.2

leak failure

failure which becomes apparent by the passage of the test liquid through the pipe wall

Note 1 to entry: Failures of the test sample have been observed at the spring-line location without leakage of the test liquid. While leakage is not observed, this can be considered a failure of the test sample as the strain levels in the sample will be altered, invalidating any continuation of the test. The test can be discarded or optionally counted as a failure occurring at the time of spring-line breakage.

4 Principle

The interior of a test piece is exposed to a corrosive test liquid at a specified temperature while being maintained in a fixed diametrically deflected condition. The test is repeated at several deflection levels, using a fresh test piece each time and recording the time to leak failure at each deflection. The results are used to calculate an extrapolated deflection value for a specified period of time.

Alternatively, the extrapolation can be performed using calculated or measured strains. Strain can be measured using strain gauges.

NOTE Use of strain allows testing using test pieces of variable thickness and stiffness classes. Deflection and strain are interrelatable by calculation.

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

- a) the composition of the test liquid (see [Clause 5](#));
- b) the number and length of test pieces (see [Clause 7](#));
- c) the preconditioning to be applied (see [Clause 9](#));
- d) the test temperature (see [10.1](#) or [11.1](#));
- e) if failures do not occur (see [10.11](#) and [11.11](#)), the specified deflection levels and related minimum time intervals;
- f) the time to which the data shall be extrapolated (see [Clause 12](#)).

5 Test liquid

The test liquid shall be as specified in the referring International Standard. The quantity shall be sufficient to achieve and maintain for the duration of the test the specified depth within the test piece (see [10.7](#) or [11.7](#)).

6 Apparatus

6.1 Loading frame

The frame comprises two parallel steel sections and threaded rods which can maintain a constant deflection of the test piece (see [Figure 1](#) for typical test set-up). The sections shall be sufficiently stiff such that visible bending or deformation of the sections does not occur during the compression of the

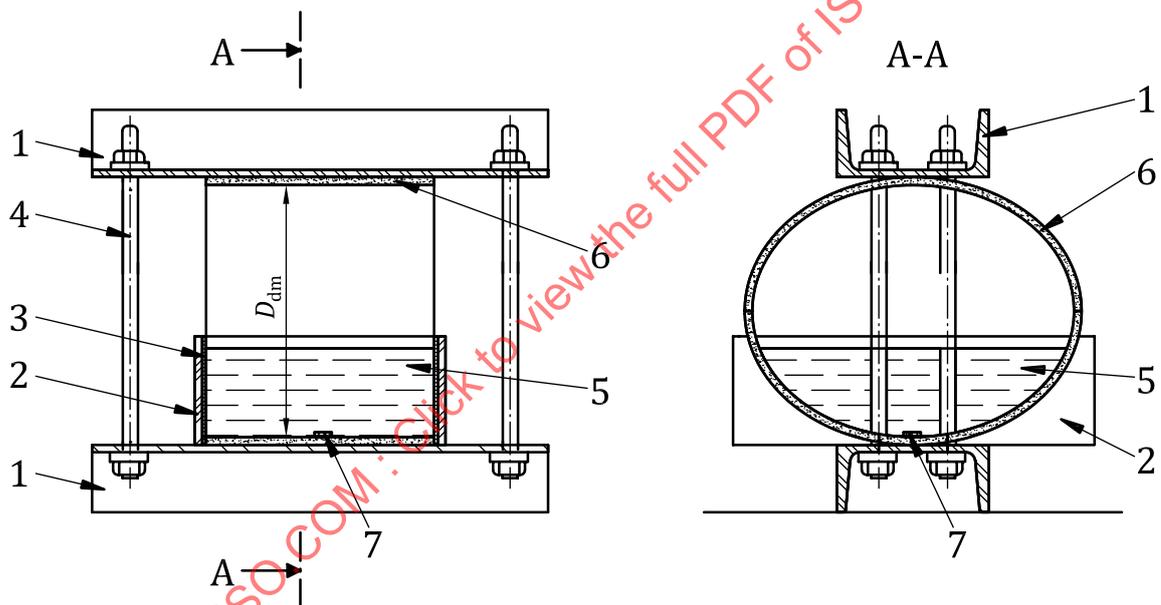
test piece. Each section shall have a length equal to the length of the test piece, plus at least 30 mm and a width of at least 100 mm.

6.2 Dimensional measuring devices

These devices shall determine:

- the dimensions (length, diameter, and wall thickness) of the test pieces. The devices shall be calibrated to an accuracy of within $\pm 1,0\%$;
- the change in diameter of the test piece in the vertical direction. The device shall be calibrated to an accuracy of within $\pm 1,0\%$;
- if used, strain gauges of the foil type, single element suitable for the maximum anticipated strain level, and a length appropriate for the pipe diameter.

Strain gauges of length 6 mm and 12 mm have been found to be effective for pipe diameters 300 mm to 600 mm. Consult the strain gauge manufacturer for gauge length recommendations for other pipe diameters.



Key

- | | | | |
|---|-----------------------|----------|-------------------------|
| 1 | steel channel section | 5 | test liquid |
| 2 | dam | 6 | test piece |
| 3 | sealant | 7 | strain gauge (optional) |
| 4 | threaded rod | D_{dm} | deflected diameter |

Figure 1 — Typical test set-up

7 Test pieces

7.1 Preparation

The test piece shall comprise a complete ring cut from the pipe or fitting to be tested. The length of the test piece shall be as specified in the referring International Standard, with permitted deviations of $\pm 5\%$.

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

Two straight lines, diametrically opposed, shall be drawn longitudinally on the inside of the test piece.

7.2 Number

The number of test pieces shall be as specified in the referring International Standard, provided that for regression analysis, the number of test pieces is such that a minimum of 18 data points in accordance with [10.2](#) or [11.2](#) can be obtained.

8 Determination of the dimensions of the test piece

8.1 Length

Measure the length of the test piece along each line with sufficient accuracy to determine whether or not each test piece conforms with the requirements of [Clause 7](#). Trim or replace, as applicable, each test piece that does not conform.

8.2 Mean wall thickness

Measure ([6.2](#)) the wall thickness of the test piece at six equally spaced locations along one of the longitudinal lines specified in [7.1](#). (This line then becomes the bottom of the test piece.) Calculate the mean wall thickness, e_m , as the arithmetic average of the six measured values.

8.3 Mean diameter

Measure ([6.2](#)) either the internal diameter, d_i , of the test piece at mid-length, by means of, for example, a calliper, or the external diameter, d_e , of the test piece, by means of, for example, a circumferential wrap steel tape.

Determine the mean diameter, d_m (see [3.1](#)), of the test piece by calculation using the values obtained for mean wall thickness, e_m , and either the internal or the external diameter.

9 Conditioning

Unless otherwise specified by the referring International Standard, the test pieces shall be stored under testing conditions for at least 8 h.

10 Test procedure using deflection measurement

WARNING — Contain any fragmentation or leakage that can occur during the test.

10.1 During the following procedure, maintain the temperature specified in the referring International Standard.

10.2 Select the range of estimated deflections such that the times to failure of at least 18 test pieces are distributed between 0,1 h and over 10 000 h, and the distribution of failure times of at least 10 values conforms to the limits given in [Table 1](#).

Table 1 — Failure time distribution

Failure time t_f h	Minimum number of failures
$10 \leq t_f \leq 1\,000$	4
$1\,000 < t_f \leq 6\,000$	3
$t_f > 6\,000$	3 ^a
^a At least one of these shall exceed 10 000 h.	

10.3 Place the test piece in the apparatus such that the lines on the test piece are vertically aligned, parallel to, and centred on the axes of the plates or sections.

By visual inspection, ensure that the contact between the test piece and loading apparatus is as uniform as possible and that the plates or sections are not tilted.

10.4 Apply force to the apparatus to deflect the test piece while keeping the top and bottom plates or sections of the apparatus as parallel as possible.

When the applicable deflection is reached (see [10.2](#)), note the time and lock the apparatus to maintain the test piece in the deflected condition.

10.5 Using a flexible sealant, install chemically inert dams so that only the inside surface of the test piece is exposed to the test environment. The dams shall not add support to the test piece.

10.6 Calculate the initial linear strain level, ϵ_0 , expressed as a percentage, using [Formula \(1\)](#), which includes compensation for increased horizontal diameter with increasing deflection:

$$\epsilon_0 = \frac{4,28 \times e_m \times \Delta y \times 100}{\left(d_m + \frac{\Delta y}{2}\right)^2} \quad (1)$$

where

e_m is the mean wall thickness, in millimetres, of the test piece at the bottom (see [8.2](#));

Δy is the average vertical deflection, in millimetres, equal to $d_i - D_{dm}$, where D_{dm} is the deflected diameter, in millimetres (see [Figure 1](#)), and d_i is the internal diameter (see [3.1](#));

d_m is the mean diameter, in millimetres, of the test piece (see [3.1](#)).

The calculation assumes that the neutral axis is at the test piece wall midpoint. For test piece wall constructions that produce an altered neutral axis position, it can be necessary to evaluate results substituting $2d$ for e , where d is the distance from the inside pipe surface to the neutral axis. The neutral axis position should be determined using strain gauge couples ([6.2](#)).

NOTE Deflections in excess of 28 % of diameter can cause local flattening of the pipe and lead to strain distribution which cannot be easily be computed. For deflections approaching 28 %, improved accuracy is obtained by use of additional strain gauges or by establishing, for a typical test piece, a calibration of deflection versus measured strain. This calibration technique is also useful at all deflection levels as a check of the calculations which assume that the neutral axis is at the midpoint of the test piece wall.

10.7 Within 2 h of the test piece reaching the selected deflection (see [10.4](#)), introduce the test liquid between the dams to a depth of between 25 mm and 50 mm and record the time as the zero time.

The time permitted between loading the test piece and the zero time is chosen to minimize differences arising from stress relaxation. This time has also been chosen to facilitate preparation of the test piece.

10.8 Maintain the depth of the test liquid at not less than 25 mm until leak failure occurs or the test is stopped. For the duration of the exposure of the test piece, periodically check using suitable analytical methods and, if necessary, adjust the test solution to maintain it within $\pm 5\%$ of the specified concentration.

NOTE Solutions become more concentrated by the evaporation of water. It can be necessary, with some reagents, to clean the deflected test piece periodically and to replace the test solution with a fresh solution. A plastic film, cut carefully to fit between the dams and floated on top of the test solution, reduces evaporation.

10.9 Unless otherwise specified, inspect the test piece visually, without magnification, for signs of leak failure at the intervals given in [Table 2](#), subject to the permitted deviations given in the rightmost column.

When a test solution is being replaced by a fresh solution, a detailed examination of the wet area can be made. Any visual observations such as cracking or delamination should be recorded.

To improve visibility of leak failure, if necessary, prepare the outer surface of the test piece by coating with a lime wash. The use of electronic timers has been found helpful in monitoring time to failure particularly on short-term tests.

Table 2 — Inspection intervals

Time since zero time h	Inspection interval	Permitted deviations on inspection interval
0 to 10	every 1 h	$\pm 0,25$ h
10 to 600	every 24 h	± 6 h
600 to 6 000	every 72 h	± 10 h
> 6 000	every week	± 1 d

10.10 Record the time to failure for each test piece. Test pieces that have not failed after more than 10 000 h can be included as failures to establish the regression line. The non-failed test pieces can be left under test and the regression line recalculated as failures are obtained.

10.11 In the event that failures do not occur at any time, implement alternative procedures (typically called specified levels) as detailed in the referring International Standard or ISO 23856.

11 Test procedure using strain measurement

WARNING — Contain any fragmentation or leakage that can occur during the test.

11.1 During the following procedure, maintain the temperature as specified in the referring International Standard.

11.2 Select the range of estimated strains such that the times to failure of at least 18 test pieces are distributed between 0,1 h and over 10 000 h, and the distribution of failure times of at least 10 values conforms to the limits given in [Table 1](#).

11.3 Carefully align and attach three strain gauges ([6.2](#)) on the invert of the test piece in the circumferential direction to measure initial circumferential strain. Place the gauges equally spaced along one of the lines of the test piece. The adhesive used to attach the gauges shall, in total, not cover more than 37 % of the test piece length along the invert. Zero the gauges while the test piece is circular in shape.

It is recommended that the test piece be placed with its axis vertical to maintain roundness when the bridge is balanced to zero the instrument.

11.4 After installing the strain gauges, place the test piece in the test set-up (see [Figure 1](#)) with the strain gauges at the bottom. Take extreme care to ensure that the gauges are located at the point of maximum

strain (the “6 o'clock” position), and that the lines on the test piece are parallel to and centred on the axes of the plates or sections.

IMPORTANT — Alignment of the test piece within the loading frame is critical.

11.5 Apply force to the apparatus to deflect the test piece while keeping the top and bottom plates or sections of the apparatus as parallel as possible. When the desired strain level is reached, lock the apparatus to maintain the test piece in the deflected condition. Read the gauges as soon as the apparatus is locked.

Record the initial strain measured by each strain gauge within 2 min after locking the apparatus. To validate the test condition, check that at least two gauges give readings within $\pm 2,5$ % of the mean value. If any gauge reads more than 7,5 % from the average of the other two gauges, disregard the indication unless a thickness verification implies the strain gauge reading was accurate.

Average the valid gauge indications, and record as the initial strain.

11.6 Using a flexible sealant, install chemically inert dams so that only the inside surface of the test piece will be exposed to the test environment and the dams do not add support to the test piece.

11.7 Within 2 h of reaching the selected strain (see [11.2](#)), introduce test liquid between the dams to a depth of between 25 mm and 50 mm and record the time as the zero time.

NOTE The time permitted between loading the test piece and the zero time is chosen to minimize differences arising from stress relaxation. This time has also been chosen to facilitate preparation of the test piece.

11.8 Maintain the depth of the test liquid at not less than 25 mm until failure occurs or the test is stopped. For the duration of the exposure of the test piece, periodically check and, if necessary, adjust the test solution to maintain it within ± 5 % of the specified concentration.

NOTE Solutions become more concentrated by the evaporation of water. It can be necessary, with some reagents, to clean the deflected test piece periodically and replace the test solution with a fresh solution. A plastic film, cut carefully to fit between the dams and floated on top of the test solution, reduces evaporation.

11.9 Unless otherwise specified, inspect the test piece visually, without magnification, for signs of leak failure at the intervals given in [Table 2](#), subject to the permitted deviations given in the rightmost column.

NOTE When a test solution is being replaced by a fresh solution, an intensive examination of the wet area can be made.

To improve visibility of leak failure, if necessary, prepare the outer surface of the test piece by coating with a lime wash. The use of electronic timers has been found helpful in monitoring time to failure, particularly on short-term tests.

11.10 Record the time to failure for each test piece. Test pieces that have not failed after more than 10 000 h can be included as failures to establish the regression line. Using the results from non-failed test pieces will result in a lower extrapolated strain. The non-failed test pieces can be left under test, and the regression line recalculated as failures are obtained.

11.11 In the event that failures do not occur at any time, implement the procedure using specified levels as detailed in the referring International Standard or ISO 23856.

12 Calculation of extrapolated value

Using the data obtained in accordance with [Clause 10](#) or [Clause 11](#), determine in accordance with ISO 10928, method A, the extrapolated deflection or strain value at the relevant time specified in the referring International Standard.