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**Plastics piping systems for non-pressure underground conveyance and storage of non-potable water — Arch-shaped, corrugated wall chambers made of PE or PP used for retention, detention, storage and transportation of storm water systems — Product specifications and performance criteria**

*Systèmes de canalisations en plastique pour le transport et le stockage souterrains sans pression de l'eau non potable — Chambres en forme d'arche en PE ou PP, à parois annelées, utilisées pour les systèmes de transport, de stockage et de rétention des eaux pluviales — Spécifications des produits et critères de performance*

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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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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](http://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 1, *Plastics pipes and fittings for soil, waste and drainage (including land drainage)*.

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](http://www.iso.org/members.html).

## Introduction

This document specifies systems comprised of arch-shaped, corrugated wall chambers made of PE or PP and used for infiltration, attenuation and storage of storm water.

At the time of drafting, the drafting committee is not aware of the existence of chambers made of unplasticized polyvinylchloride (PVC-U) materials. If unplasticized polyvinylchloride (PVC-U) chambers are produced and become available on the market, they will be included in a future revision of this document.

The arch-shaped, corrugated wall chambers and end caps are part of a buried structural system which includes both the arch-shaped chamber, end caps and the surrounding backfill material. Proper design of installed arch-shaped, corrugated wall chamber systems requires consideration of the structural contribution from the surrounding backfill materials and conformity with installation guidelines.

Arch-shaped chambers are installed as one horizontal layer on a firm foundation and embedded with fill around and above each individual unit.

Although differing in geometry, when properly installed, the structural behaviour of chambers is similar to that of circular thermoplastic pipes. Guidance for structural design can be found in ASTM F2787.<sup>[1]</sup>

Guidance for installation can be found in [Annex G](#).

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# Plastics piping systems for non-pressure underground conveyance and storage of non-potable water — Arch-shaped, corrugated wall chambers made of PE or PP used for retention, detention, storage and transportation of storm water systems — Product specifications and performance criteria

## 1 Scope

This document gives the definitions and specifies the minimum requirements for injection moulded and thermoformed thermoplastics corrugated arch-shaped chambers, including integral components, used in underground systems for retention, detention, transportation and storage of non-potable water (e.g. storm water) and manufactured from polyethylene (PE) or polypropylene (PP).

These chambers are intended for buried underground use in one horizontal layer, e.g. in landscape, pedestrian or vehicular traffic areas.

In the case of retention and detention systems, the main purpose of the chambers is to retain water, for later infiltration in the ground or for later use in non-potable applications (irrigation, cleaning, sanitary facilities, etc.) or to detain water during a storm, transferring it in a controlled way to the public storm water network.

Applications include commercial, residential, agricultural and highway drainage, including installation under parking lots and roadways.

Product performance is determined by a combination of material specification, product design and manufacturing process.

These chambers are intended to be used as elements in a modular system where the manufacturer has provided a clearly documented method specifying how the components are assembled to create a complete retention, detention, storage or transportation system.

## 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 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 472, *Plastics — Vocabulary*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 580:2005, *Plastics piping and ducting systems — Injection-moulded thermoplastics fittings — Methods for visually assessing the effects of heating*

ISO 604, *Plastics — Determination of compressive properties*

ISO 899-2, *Plastics — Determination of creep behaviour — Part 2: Flexural creep by three-point loading*

ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

ISO 1133-1, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

ISO 1167-1:2006, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 1183-1, *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pycnometer method and titration method*

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

ISO 3127, *Thermoplastics pipes — Determination of resistance to external blows — Round-the-clock method*

ISO 3451-1, *Plastics — Determination of ash — Part 1: General methods*

ISO 9967:2016, *Thermoplastics pipes — Determination of creep ratio*

ISO 9969, *Thermoplastics pipes — Determination of ring stiffness*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)*

ISO/TS 28037:2010, *Determination and use of straight-line calibration functions*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472, ISO 1043-1 and the following apply.

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

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

#### 3.1 General terms

##### 3.1.1 arch-shaped chamber

arch-shaped product which defines a subsurface open space when installed

Note 1 to entry: Arch-shaped chambers may have perforations, inspection ports or other features that may or may not reduce the mechanical capacity of a chamber.

##### 3.1.2 end cap

arch-shaped product which covers the open end of a chamber row

##### 3.1.3 corrugation

periodic shape of arch-shaped chamber or end cap walls

Note 1 to entry: A wall profile consists of a regular pattern of alternating crests and valleys connected by webs.

#### 3.1.4 system

construction consisting of a single horizontal layer of connected arch-shaped chambers and end caps and associated with backfill material

#### 3.1.5 detention system

system designed to reduce the peak flow from a given site by providing a temporary underground storm water storage facility

Note 1 to entry: Also known as "attenuation".

#### 3.1.6 retention system

system designed to provide a temporary underground storage facility from which storm water infiltrates into the surrounding ground

Note 1 to entry: Also known as "infiltration".

#### 3.1.7 storage system

system designed to provide an underground storage facility for storm water

#### 3.1.8 type testing

initial testing performed according to the testing requirements in this document, the results of which are the specified requirements of the specific product being tested

Note 1 to entry: See ISO/IEC 17000:2020, 5.1, for a definition of "specified requirements".

### 3.2 Material terms

#### 3.2.1 virgin material

material in a form such as granules or powder that have not been subjected to use or processing other than that required for their manufacture and to which no reprocessed or recycled material has been added

#### 3.2.2 non-virgin material

material from used or unused infiltration and attenuation chambers and end caps which have been cleaned and crushed or ground, or material from used or unused PP or PE products other than infiltration and attenuation chambers and end caps, regardless of where they are manufactured

#### 3.2.3 agreed specification

relevant material characteristics agreed between the supplier of the material and the chamber and end cap manufacturer

### 3.3 Mechanical terms

#### 3.3.1 flattening capacity

specific mechanical characteristic of arch-shaped chambers determined in the arch stiffness test

#### 3.3.2 arch stiffness constant

ASC

specific mechanical characteristic of arch-shaped chambers determined in arch stiffness test (kN/m)

### 3.3.3

#### end cap stiffness constant

CSC

specific mechanical characteristic of end caps determined in shell stiffness test (kN)

### 3.3.4

#### stub compression strength

short-term compression strength expressed as the maximum force per length of chamber wall obtained during a specified constant displacement rate compression test of a small section of chamber wall (see [Annex D](#)) (kN/m)

## 4 Symbols and abbreviated terms

### 4.1 Symbols

For the purposes of this document, the following symbols apply.

$A$	area of chamber wall ( $\text{mm}^2/\text{mm}$ ) in x-y-plane at feet and y-z-plane at crown
$C_{AS}$	arch stiffness constant
$C_{ES}$	end cap stiffness constant
$e$	measured wall thickness at any point of a chamber
$e_c$	linear distance in radial direction from bottom surface of the valley to the outer surface of the crest, taken in a particular spot in the chamber
$F$	loading force
$G$	average weight of soil
$h$	maximum cover over the crown of the chamber according to the manufacturer's installation manual
$H$	maximum vertical outside dimension (y-direction) of chamber from bottom to top
$I$	moment of inertia of chamber wall around x-axis ( $\text{mm}^4/\text{mm}$ )
$L$	maximum horizontal outer dimension (z-direction) of chamber from one end to the other
$L_{ASC}$	length of chamber in arch stiffness test
$R$	maximum vertical clear inside dimension (y-direction) of chamber from bottom to top
$R_0$	initial rise
$S$	maximum horizontal clear inside dimension (x-direction) of chamber at feet
$W$	maximum horizontal outside dimension (x-direction) of chamber at feet
$\Delta y$	test deflection
$\varphi_i$	creep ratio from stub compression testing (with index $i$ being the number of tests)
$\varphi_{0,25}$	creep ratio from stub compression testing at a load level defined as 25 % of strength

### 4.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

ASC	arch stiffness constant
CSC	end cap stiffness constant
MFR	melt mass-flow rate
OIT	oxidation induction time
PE	Polyethylene
PP	Polypropylene

## 5 Material

### 5.1 General

The material shall be either PE or PP, to which may be added:

- mineral modifier(s) of known specification;
- additives needed to facilitate the manufacture of components conforming to this document.

The material used to manufacture the arch-chambers or end caps shall consist of a material or mixtures of different materials each of which shall have an agreed specification between supplier and manufacturer (see [Annex A](#)).

### 5.2 Polyethylene (PE) material

#### 5.2.1 General

The material shall be either PE virgin, PE modified or PE non-virgin material, conforming to [5.2.2](#) – [5.2.4](#), as appropriate.

#### 5.2.2 Polyethylene (PE) virgin material

The material for arch-shaped chambers and end caps shall be a compound of PE virgin material and those additives that are needed to facilitate the manufacture of arch-shaped chambers and end caps conforming to the requirements of this document.

When reworked material is added to a level of less than 10 %, the material for chambers can still be considered as virgin.

#### 5.2.3 Polyethylene (PE) modified with minerals

The material for arch-shaped chambers and end caps shall be a compound of PE virgin material modified with minerals and those additives that are needed to facilitate the manufacture of arch-shaped chambers and end caps conforming to the requirements of this document.

If calcium carbonate is used, only coated calcium carbonate shall be used.

The content of minerals in the final compound shall be less than 50 % by mass.

When reworked material is added to a level of less than 10 %, the material for chambers can still be considered as modified.

#### 5.2.4 Polyethylene (PE) non-virgin material

The material for arch-shaped chambers and end caps shall be a compound of non-virgin PE material, and those additives that are needed to facilitate the manufacture of arch-shaped chambers and end caps conforming to the requirements of this document.

Non-virgin materials shall be permitted to be used up to 100 % or added to virgin or reworked material or a mixture of those two materials.

The content of minerals in the final compound shall be less than 50 % by mass.

### 5.3 Polypropylene (PP) material

#### 5.3.1 General

The material shall be either PP virgin, PP modified, or PP non-virgin material, conforming to [5.3.2](#) – [5.3.4](#) as appropriate.

#### 5.3.2 Polypropylene (PP) virgin material

The material for arch-shaped chambers and end caps shall be a compound of PP virgin material and those additives that are needed to facilitate the manufacture of chambers or end caps conforming to the requirements of this document.

When reworked material is added to a level of less than 10 %, the material for chambers can still be considered as virgin.

#### 5.3.3 Polypropylene (PP) modified with minerals

The material for arch-shaped chambers and end caps shall be a compound of PP virgin material modified with minerals and those additives that are needed to facilitate the manufacture of arch-shaped chambers and end caps conforming to the requirements of this document.

If calcium carbonate is used, only coated calcium carbonate shall be used.

The content of minerals in the final compound shall be less than 50 % by mass.

When reworked material is added to a level of less than 10 %, the material for chambers can still be considered as modified.

#### 5.3.4 Polypropylene (PP) non-virgin material

The material for arch-shaped chambers and end caps shall be a compound of non-virgin PP material, and those additives that are needed to facilitate the manufacture of arch-shaped chambers and end caps conforming to the requirements of this document.

Non-virgin materials shall be permitted to be used up to 100 % or added to virgin or reworked material or a mixture of those two materials.

The content of minerals in the final compound shall be less than 50 % by mass.

### 5.4 Chamber and end cap material characteristics

A product in this document is formed by a combination of a material specification, a design and a manufacturing process. [Table 1](#) specifies the minimum required tests to fingerprint the material and to partly specify the material requirements.

In conformance with the results from type testing, a product specific material specification with specified requirements shall be defined by the manufacturer.

When tested after type testing in accordance with the test methods as specified in [Table 1](#), using the indicated parameters, the material used for the chambers and end caps shall have the characteristics conforming to the requirements given in [Table 1](#).

**Table 1 — Material characteristics of chambers and end caps**

Characteristic	Material	Requirement	Test parameters	Test method
Tensile strength – Short term	PE	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test speed: 50 mm/min Specimen type: 1A (ISO 527-2)	ISO 527-2
	PP	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test speed: 50 mm/min Specimen type: 1A (ISO 527-2)	ISO 527-2
Tensile modulus – short term	PE	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test speed: 1 mm/min	ISO 527-2
	PP	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test speed: 1 mm/min	ISO 527-2
Flexural-creep modulus – 500 h	PE	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test duration: 500 h Test stress: 2,0 MPa Temperature: (23 ± 2) °C	ISO 899-2
	PP	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Test duration: 500 h Test stress: 2,0 MPa Temperature: (23 ± 2) °C	ISO 899-2
Resistance to internal pressure	PE	No failure during the test period.	Test temperature: 80 °C Circumferential stress: 4,0 MPa Test duration: 165 h Type of test: water-in-water or water-in-air End caps: Type A or B (ISO 1167-1:2006) Orientation: Free Number of test pieces: 3 Conditioning period: in accordance with ISO 1167-1	ISO 1167-1 and ISO 1167-2
<sup>a</sup> The specified requirement is generated from type testing of the product using the tests and parameters given in this table.				

Table 1 (continued)

Characteristic	Material	Requirement	Test parameters	Test method
		No failure during the test period.	Test temperature: 80 °C Circumferential stress: 2,8 MPa Test duration: 1 000 h Type of test: water-in-water or water-in-air End caps: Type A or B (ISO 1167-1:2006) Orientation: free Number of test pieces: 3 Conditioning period: in accordance with ISO 1167-1	ISO 1167-1 and ISO 1167-2
	PP	No failure during the test period.	Test temperature: 80 °C Circumferential stress: 4,2 MPa Test duration: 140 h Type of test: water-in-water or water-in-air End caps: Type A or B (ISO 1167-1) Orientation: free Number of test pieces: 3 Conditioning period: in accordance with ISO 1167-1	ISO 1167-1 and ISO 1167-2
		No failure during the test period.	Test temperature: 95 °C Circumferential stress: 2,5 MPa Test duration: 1 000 h Type of test: water-in-water or water-in-air End caps: Type A or B (ISO 1167-1) Orientation: Free Number of test pieces: 3 Conditioning period: in accordance with ISO 1167-1	ISO 1167-1 and ISO 1167-2
Melt mass-flow rate before processing	PE	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Temperature: 190 °C Loading mass: 5 kg	ISO 1133-1
	PP	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Temperature: 230 °C Loading mass: 2,16 kg	ISO 1133-1
<sup>a</sup> The specified requirement is generated from type testing of the product using the tests and parameters given in this table.				

Table 1 (continued)

Characteristic	Material	Requirement	Test parameters	Test method
OIT before processing	PE	≥ 20 min	Temperature: 200 °C	ISO 11357-6
	PP	≥ 8 min	Temperature: 200 °C	ISO 11357-6
<sup>a</sup> The specified requirement is generated from type testing of the product using the tests and parameters given in this table.				

## 6 General characteristics for arch-shaped chambers and end caps

### 6.1 Appearance

When viewed without magnification, the internal and external surfaces shall be smooth, clean and free from defects likely to prevent conformity with this document. Sharp edges in the external surface shall be avoided.

### 6.2 Colour

Any colour may be used.

## 7 Geometrical characteristics

### 7.1 General

All dimensions shall be measured in accordance with ISO 3126.

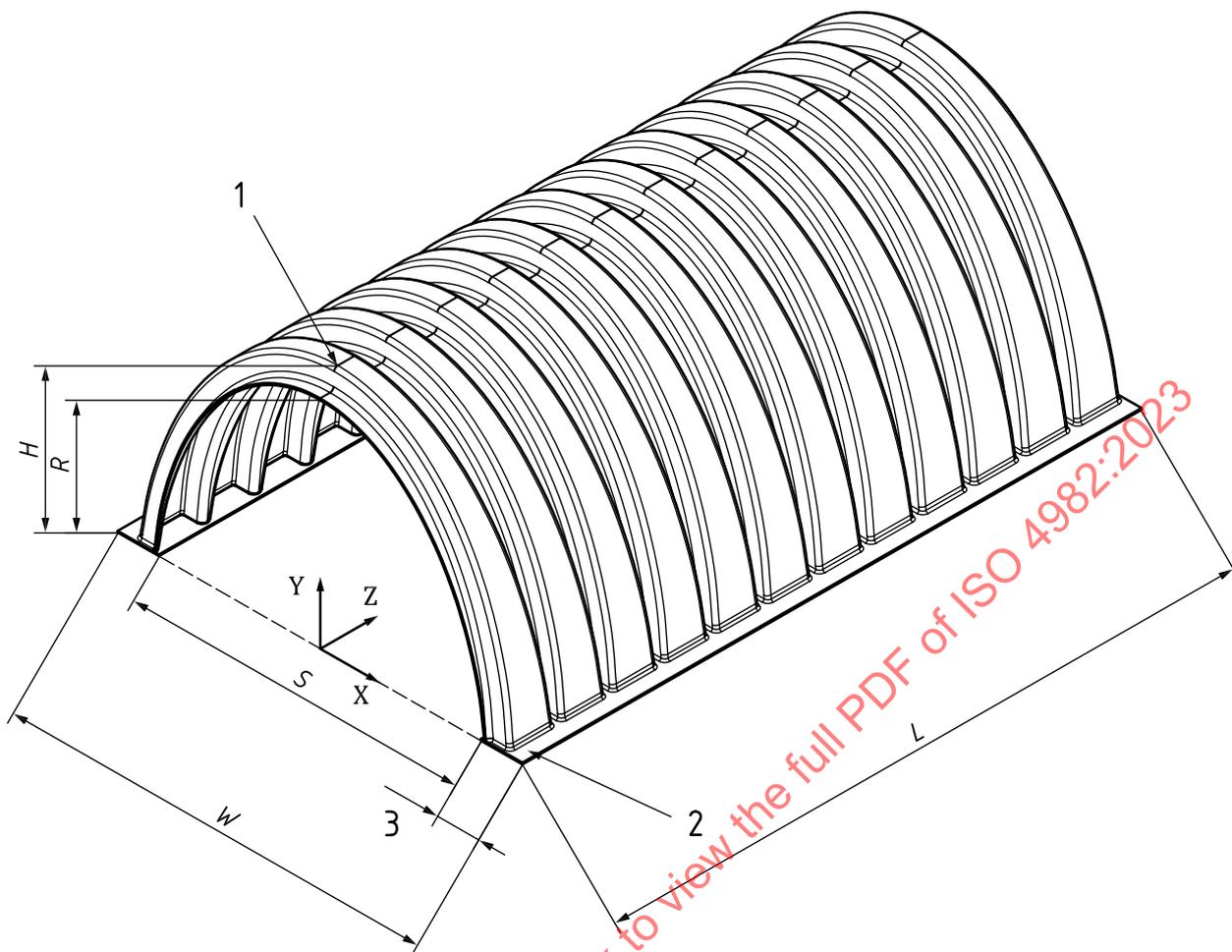
The wall thickness at any point shall be at least 2,5 mm ( $e \geq 2,5$  mm).

The dimensions shall be according to the specification given by the manufacturer.

The maximum span of a chamber is 2 500 mm and the maximum rise 1 500 mm. The span to rise ratio shall be 1,5 to 2,0.

The length of the chamber,  $L$ , shall not be less than that specified by the manufacturer.

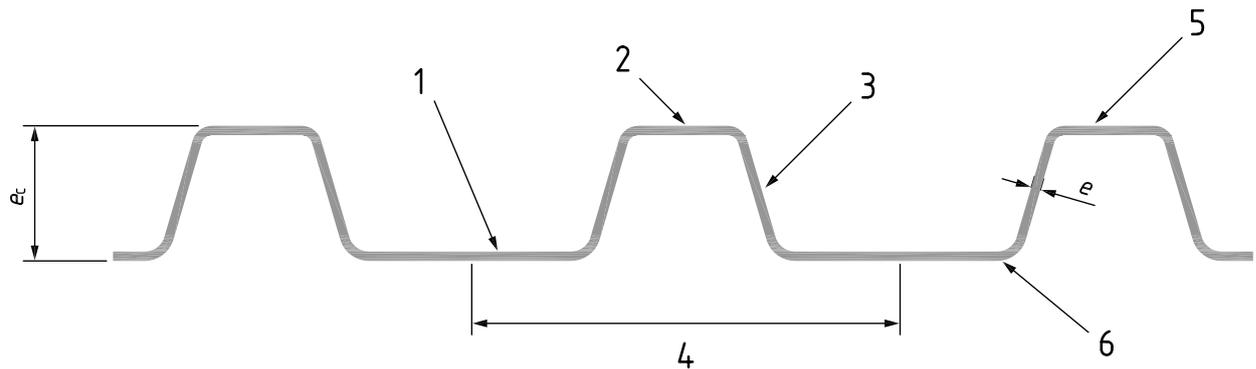
Typical schematic displays of an arch-shaped chamber and its corrugations are shown in [Figure 1](#) and [Figure 2](#), respectively.



**Key**

- 1 crown
- 2 foot
- 3 foot width

**Figure 1 — Schematic display of chamber**

**Key**

- 1 valley
- 2 crest
- 3 web
- 4 period
- 5 chamber exterior
- 6 chamber interior

**Figure 2 — Schematic display of corrugation**

## 7.2 Volume

The volume of the chambers is the available volume for water storage. It shall be obtained for chambers in accordance with [Annex F](#). The volume is used in hydraulic design. The volume of end caps is neither determined nor used in hydraulic design.

As an alternative to the test method in [Annex E](#), 3D computer modelling can be used for volume calculation.

## 7.3 Weight

The weight shall be measured with an accuracy of 0,1 %.

The reference weight shall be the mean weight obtained at arch-shaped chambers and end caps used for testing ASC and CSC according to [Annexes B](#) and [C](#).

The reference weight shall be determined during type testing and reported as a specified requirement for the product. Subsequent testing for conformity assessment shall return a value within 2 % of the specified requirement value.

## 8 Physical characteristics

### 8.1 Physical characteristics of PE chambers and end caps

When tested in accordance with the test methods specified in [Table 2](#), using the indicated parameters, the chambers and end caps shall have physical characteristics conforming to the requirements given in [Table 2](#).

**Table 2 — Physical characteristics of PE chambers and end caps**

Characteristic	Requirements	Test parameters	Test method
Effect of heating	The depth of cracks, delamination or blisters shall not be more than 20 % of the wall thickness around the injection point(s), if applicable. No part of the weld line shall open to a depth of more than 20 % of the wall thickness.	Test temperature: (110 ± 2) °C Heating time: in accordance with ISO 580:2005, Method A <sup>a</sup>	ISO 580:2005 Clause 4, Method A
<sup>a</sup> For the wall thickness, <i>e</i> , the maximum measured wall thickness of the chamber shall be taken.			

**8.2 Physical characteristics of PP chambers and end caps**

When tested in accordance with the test methods specified in [Table 3](#), using the indicated parameters, the chambers and end caps shall have physical characteristics conforming to the requirements given in [Table 3](#).

**Table 3 — Physical characteristics of PP chambers and end caps**

Characteristic	Requirements	Test parameters	Test method
Effect of heating	The depth of cracks, delamination or blisters shall not be more than 20 % of the wall thickness around the injection point(s), if applicable. No part of the weld line shall open to a depth of more than 20 % of the wall thickness.	Test temperature: (150 ± 2) °C Heating time: in accordance with ISO 580:2005, Method A <sup>a</sup>	ISO 580:2005 Clause 4, Method A
<sup>a</sup> For the wall thickness, <i>e</i> , the maximum measured wall thickness of the chamber shall be taken.			

**9 Mechanical characteristics**

When tested in accordance with the test methods specified in [Table 4](#), using the indicated parameters, the chambers and end caps shall have mechanical characteristics conforming to the requirements given in [Table 4](#).

In conformance with the results from type testing of the mechanical characteristics, the specified requirements for each specific product shall be defined by the manufacturer.

Table 4 — Mechanical characteristics of chambers and end caps

Characteristic	Requirements	Test parameters	Test method
ASC (arch stiffness constant)	$\geq 4,4$ kN/m	Deflection: 2 % Number of test pieces: 3 Length of test piece: shall incorporate at least 2 corrugations Displacement rate: $(2 \pm 0,1)$ mm/min	<a href="#">Annex B</a>
CSC (end cap stiffness constant)	$\geq 0,2$ kN	Deflection: 2 % Number of test pieces: 3 Displacement rate: 10 mm/min	<a href="#">Annex C</a>
Flattening capacity for arch-shaped chambers	No failure up to 6 % of rise	Deflection: 6 % Number of test pieces: 3 Length of test piece: shall incorporate at least 2 corrugations Displacement rate: $(2 \pm 0,1)$ mm/min	<a href="#">Annex B</a>
Flattening capacity for end caps	No failure up to 4 % of rise.	Deflection: 4 % Number of test pieces: 3 Displacement rate: $(2 \pm 0,1)$ mm/min	<a href="#">Annex C</a>
Impact strength	TIR $\leq 10$ %	Test temperature: $(0 \pm 1)$ °C Conditioning medium: water or air Type of striker: d90 Mass of striker: 3,2 kg Fall of striker: 2,0 m Length of test piece: $\geq 3$ corrugations Number of axial lines along perimeter: 8	ISO 3127
Stub compression strength per chamber width	The values obtained shall meet or exceed the specified requirement for the product being tested. <sup>a</sup>	Number of test pieces: 3 Length of test piece: shall incorporate at least 2 corrugations Displacement rate: $(1,0 \pm 0,1)$ mm/min	<a href="#">Annex D</a>
Creep ratio for 2 years on 25 % stub compression strength	PP and PE: $\leq 4$ at 2 year extrapolation.	Number of test pieces per load level: 3 Load levels: 3 Duration: 1 008 h	<a href="#">Annex E</a>

<sup>a</sup> The specified requirement generated from type testing of the product using the tests and parameters given in this table.

## 10 Marking

### 10.1 General

Marking elements shall be labelled or printed or formed directly on the arch-shaped chamber or end cap, in such a way that after storage, weathering, handling and installation, legibility is maintained.

Marking shall not initiate cracks or other types of defects which adversely influence the performance of the arch-shaped chambers or end caps.

The size of the marking shall be such that the marking is legible without magnification.

## 10.2 Minimum required marking

### 10.2.1 Arch-shaped chambers

Arch-shaped chambers shall be marked at intervals of maximum 2 m, at least once per chamber.

The minimum required marking shall conform to [Table 6](#).

**Table 6 — Minimum required marking of chambers**

Information	Marking or symbols
Number of this document	ISO 4982
Manufacturer's name and/or trademark	XXX
Material	PE or PP
Manufacturer's information	a
<sup>a</sup> This shall be given in clear figures or in a code providing traceability to the following details: <ul style="list-style-type: none"> <li>— the production period year and month;</li> <li>— the production site if the manufacturer is producing in different sites, nationally and/or internationally.</li> </ul>	

### 10.2.2 End caps

The minimum required marking shall conform to [Table 7](#).

**Table 7 — Minimum required marking of end caps**

Information	Marking or symbols
Number of this document	ISO 4982
Manufacturer's name and/or trademark	XXX
Material	PE or PP
Manufacturer's information	a
<sup>a</sup> This shall be given in clear figures or in a code providing traceability to the following details: <ul style="list-style-type: none"> <li>— the production period year and month;</li> <li>— the production site if the manufacturer is producing in different sites, nationally and/or internationally.</li> </ul>	

## Annex A (normative)

### Agreed specification between the manufacturer of the arch-shaped chambers and the supplier of the materials

#### A.1 Material characteristics

An agreed specification shall be made between the manufacturer of arch-shaped chambers and the supplier of PE or PP material.

The agreed specification shall contain at least the material characteristics listed in [Table A.1](#) in order that the materials or mixtures of different materials can be used on their own or mixed with other materials so that the final formulation conforms to the specified material requirements of this document.

**Table A.1 — Material characteristics for the agreed specification**

Characteristic	Requirement	Test parameters	Test method	Limit
Source of material	As agreed with supplier			N/A
Type of mineral modifier	As agreed with supplier			N/A
Ash residue (%)	As agreed with supplier	600 °C	ISO 3451-1	Max
Extraneous polymers	As agreed with supplier		ISO 11358-1 or IR analyses or ISO 11357-6	Max
Type of pigments or additives	As agreed with supplier			N/A
Impact strength	As agreed with supplier		ISO 179-1	Min
Density	As agreed with supplier		ISO 1183-1	In range
Tensile strength	As agreed with supplier	Speed 50 mm/min	ISO 527-2	Min
Tensile strain at yield	As agreed with supplier	Speed 50 mm/min	ISO 527-2	Min
Tensile modulus	As agreed with supplier	Speed 1 mm/min	ISO 527-2	Min
Flexural-creep modulus 500 h	As agreed with supplier	2,0 MPa	ISO 899-2	Min
Resistance to internal pressure	As agreed with supplier	PE: Temp. 80 °C Stress 4,0 MPa Time > 165 h PP: Temp. 95 °C Stress 4,2 MPa Time > 140 h	ISO 1167-1 and ISO 1167-2	Min

**Table A.1** (continued)

Characteristic	Requirement	Test parameters	Test method	Limit
Resistance to internal pressure	As agreed with supplier	PE: Temp. 80 °C Stress 2,8 MPa Time > 1 000 h PP: Temp. 95 °C Stress 2,5 MPa Time > 1 000 h	ISO 1167-1 and ISO 1167-2	Min
MFR	As agreed with supplier	For PE: Temp. 190 °C and loading mass 5 kg For PP: Temp. 230 °C Loading mass 2,16 kg	ISO 1133-1	In range
OIT	As agreed with supplier	Temp. 200 °C	ISO 11357-6	In range

## A.2 Reworked and recycled material quality

The use of clean reworked material of arch-shaped chambers and end caps conforming to [Table A.1](#) for the production of arch-shaped chambers and end caps is permitted without limitations.

It is permitted to use external reprocessed and/or recycled material from any source, provided it is covered by an agreed specification according to [Table A.1](#).

External reworked and recyclable materials not covered by an agreed specification shall not be used for the production of arch-shaped chambers and end caps conforming to this document.

## Annex B (normative)

### Arch stiffness and flattening capacity test for arch-shaped chambers

#### B.1 General

This test method covers the determination of load-deflection characteristics of arch-shaped chambers under parallel-plate loading. The characteristics determined by this test method are arch stiffness and flattening capacity of the arch-shaped chamber. This test does not determine the structural capacity of the chamber-soil structural system.

#### B.2 Principle

A test sample taken from a finished chamber is compressed between two rigid plates at a controlled rate while the feet are restrained for lateral displacement. The test reveals load versus displacement.

The ASC is calculated at a displacement of the crosshead equal to 2 % of the rise. This criterion is product-specific and different from ISO 9969.

The chamber is examined at a displacement of the crosshead equal to 6 % of the rise to evaluate the flattening capacity of the chamber. The flattening capacity is proven by deflecting to 6 % without any failure, i.e. without any splitting, cracking or breaking in the test piece or any buckling of the corrugated wall, normally accompanied with a decrease of the measured force.

The maximum load is recorded.

#### B.3 Apparatus

The test machine shall conform in principle to the diagram in [Figure B.1](#). The load is applied to the test piece through two parallel steel bearing plates. The plates shall be flat, smooth and clean, and shall be sufficiently thick to ensure that no bending or deformation of the plates occurs during the test. The plate length shall exceed the length of the test piece and the plate width shall not be less than the chamber contact width at the maximum chamber deflection plus 150 mm.

The test machine, force and deflection measuring systems shall conform to the requirements of ISO 9969.

#### B.4 Preparation of test pieces

The test pieces shall be cut from a chamber. The total length shall be a minimum of two full periods of the corrugation (see [Figure B.1](#)) and shall include the complete arch of the chamber. The test pieces shall include the features that are expected to reduce the mechanical performance, for example perforations or varying geometry. The test pieces' ends shall be cut flat and be free of burrs and jagged edges.

#### B.5 Measurement of test piece dimensions

Determine the length,  $L_{ASC}$ , of each test piece to the nearest 1,0 mm by making three measurements equally spaced around the arch. Use the average of the three measurements as the test piece length.

Determine the rise of each test piece to the nearest 1,0 mm by measuring the perpendicular distance from the plane formed by the feet according to [Figure 1](#) with no force other than the chamber weight.

Equipment for measuring test piece dimensions shall conform to the requirements of ISO 3126.

## B.6 Conditioning

The conditioning of test pieces shall conform to the requirements of ISO 9969.

## B.7 Test procedure

### B.7.1 Test temperature

The test temperature shall conform to the requirements of ISO 9969.

### B.7.2 Mounting of test pieces

Place the test piece on the lower plate of the testing machine, centring the test piece under the testing machine crosshead vertical axis as shown in [Figure B.1](#). The chamber feet shall be constrained against lateral motion at the outer edge of the foot. The feet shall be free to rotate.

### B.7.3 Applying the load

Record the load, load plate displacement and time continuously during the test.

With the external displacement indicator in place, bring the upper plate near to the test piece. Bring the upper plate into contact with the test piece until a preload force of 100 N is reached.

Compress the test piece with a constant displacement rate until the crosshead displacement becomes equal to 6 % of the original rise of the test piece, then inspect under normal light and the unaided eye and record any failure and report these findings as flattening capacity.

The displacement rate shall be  $(2 \pm 0,1)$  mm/min per metre of rise height with a minimum of  $(1 \pm 0,1)$  mm/min.

## B.8 Calculation and expression of results

Calculate the ASC,  $C_{AS}$ , expressed in kN/m per 1 % deflection, using [Formula \(B.1\)](#):

$$C_{AS} = \frac{F}{\Delta y \cdot L} \quad (\text{B.1})$$

where

$F$  is the applied load to cause vertical deflection equal to 2 % of chamber rise, in kN;

$L$  is the length of the test piece, in m;

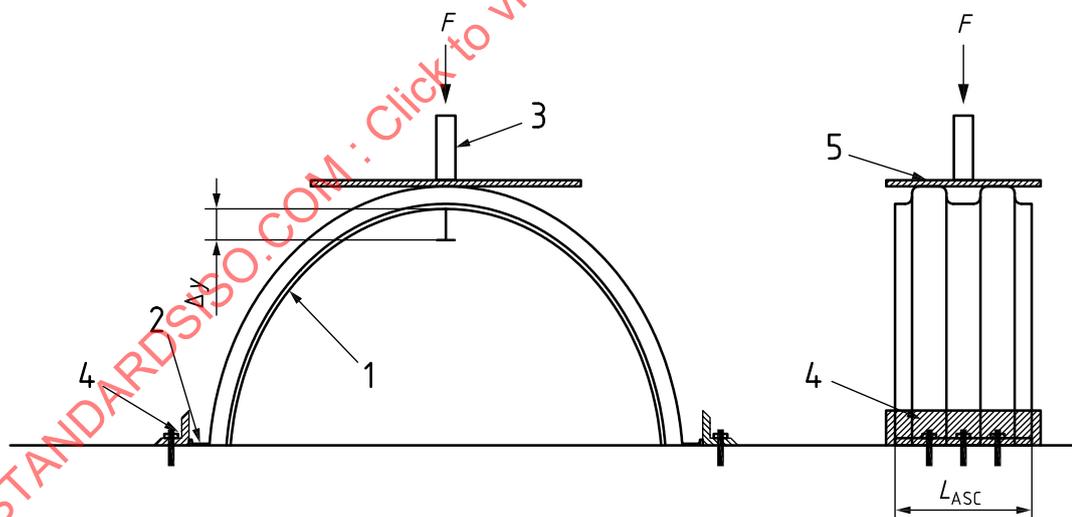
$\Delta y$  is the test deflection, as % of chamber rise (= 2).

## B.9 Test report

The test report shall include the following information:

- a) a reference to this document and this annex, i.e. ISO 4982:2023, Annex B;

- b) a complete description and identification of the chamber tested, manufacturer's code, manufacturer's product identification and resin type;
- c) the test conditions and conditioning procedures;
- d) the dimensions of each test piece;
- e) any perforations or varying geometry of the test pieces;
- f) the test temperature;
- g) the displacement rate throughout the test duration;
- h) the maximum load reached during the test, which is the chamber strength per length in kN/m;
- i) the load versus displacement diagram for the test;
- j) the accuracy grading of the test machine in accordance with ISO 9969;
- k) the arch stiffness constant (ASC) for each test piece (calculated according to [Clause B.8](#));
- l) pass or fail at 6 % deflection, i.e. flattening capacity observations;
- m) the number of the test pieces tested;
- n) any factors which may have affected the results, such as any incidents or any operating details not specified in this annex;
- o) any unusual features observed;
- p) the date of measurement.



**Key**

- 1 chamber sample
- 2 foot
- 3 upper plate
- 4 foot restraint
- 5 load plate

**Figure B.1 — Test piece in position at the start of the test**

## Annex C (normative)

### Stiffness and flattening capacity test for end caps

#### C.1 General

This test method covers the determination of load-deflection characteristics of thermoplastic end caps under parallel-plate loading. The characteristics determined by this test method are end cap stiffness and flattening capacity of the end cap. This test does not determine the structural capacity of the end cap-soil structural system.

#### C.2 Principle

A complete end cap sample is used. The end cap edges are restrained and the test piece is compressed between two rigid plates at a controlled rate. The test reveals force versus displacement. The force, displacement of the plates and time are recorded at a constant cross head displacement rate.

The force at 2 % displacement is used to calculate the end cap stiffness constant (CSC). The end cap is examined at a displacement of 4 % of the rise to evaluate the capacity of the end cap to deflect the load without structural damage, i.e. without any splitting, cracking or breaking in the test piece or any buckling of the corrugated wall, normally accompanied with a decrease of the measured force. The maximum load is recorded.

#### C.3 Apparatus

The test machine shall conform in principle to the diagram in [Figure C.1](#). The end caps are restrained from spreading by a full perimeter restraint. The force is applied to the test piece through two parallel steel bearing plates. The upper plate is connected to a force application plate. The plates shall be flat, smooth and clean, and shall be sufficiently thick such that no bending or deformation of the plates occurs during the test.

In all other respects, the test machine, force, deflection measuring systems and temperature shall conform to the requirements of ISO 9969.

#### C.4 Measurement of test piece dimensions

Determine the outer dimensions of each test piece in all three directions to the nearest 1,0 mm.

Equipment for measuring test piece dimensions shall conform to the requirements of ISO 3126.

#### C.5 Conditioning

The conditioning of test pieces shall conform to the requirements of ISO 9969.

#### C.6 Procedure

##### C.6.1 Test temperature

The test temperature shall conform to the requirements of ISO 9969.

### C.6.2 Mounting of test pieces

Place the test piece on the lower plate of the testing machine, centring the loading area of the test piece under the testing machine crosshead vertical axis as shown in [Figures C.1 a\)](#) and [C.1 b\)](#). The end cap edges shall be constrained against lateral and vertical motion as shown in [Figures C.1 a\)](#) and [C.1 b\)](#). The edges shall be free to rotate.

### C.6.3 Applying the load

The force application area shall have a maximum length and width of 500 mm, respectively. It is permitted to use timber wedges screwed to the end caps from inside to maximize the direct contact area of the end cap with the loading plate. With the external displacement indicator in place, bring the force application plate into contact with the test piece with no more load than is necessary to hold the test piece in place. Use no more than 100 N preload force.

A crosshead motion of 10 mm/min shall be applied.

### C.6.4 Measurement of end cap height

Measure the end cap height,  $y$ , from the bottom load plate to the inner end cap surface in the vertical axis of the loading area at the distance  $1/3 H_{EC}$  from the bottom of the end cap, as shown in [Figure C.1](#).

### C.6.5 Deflection measurement

Record the load, load plate displacement and time continuously. Record the load at 2 % vertical deflection. After recording the load at 2 % deflection, continue the test at the same crosshead speed until the vertical deflection equals 4 % of the original rise, then inspect under normal light and the unaided eye.

## C.7 Calculation and expression of results

### C.7.1 Calculation of end cap stiffness constant (CSC)

Calculate the end cap stiffness constant,  $C_{ES}$ , expressed in kN per 1 % deflection, using [Formula \(C.1\)](#):

$$C_{ES} = \frac{F}{\Delta y} \quad (C.1)$$

where

$F$  is the plate load to cause 2 % vertical deflection, in kN;

$\Delta y$  is the test deflection, in % (= 2).

### C.7.2 Flattening

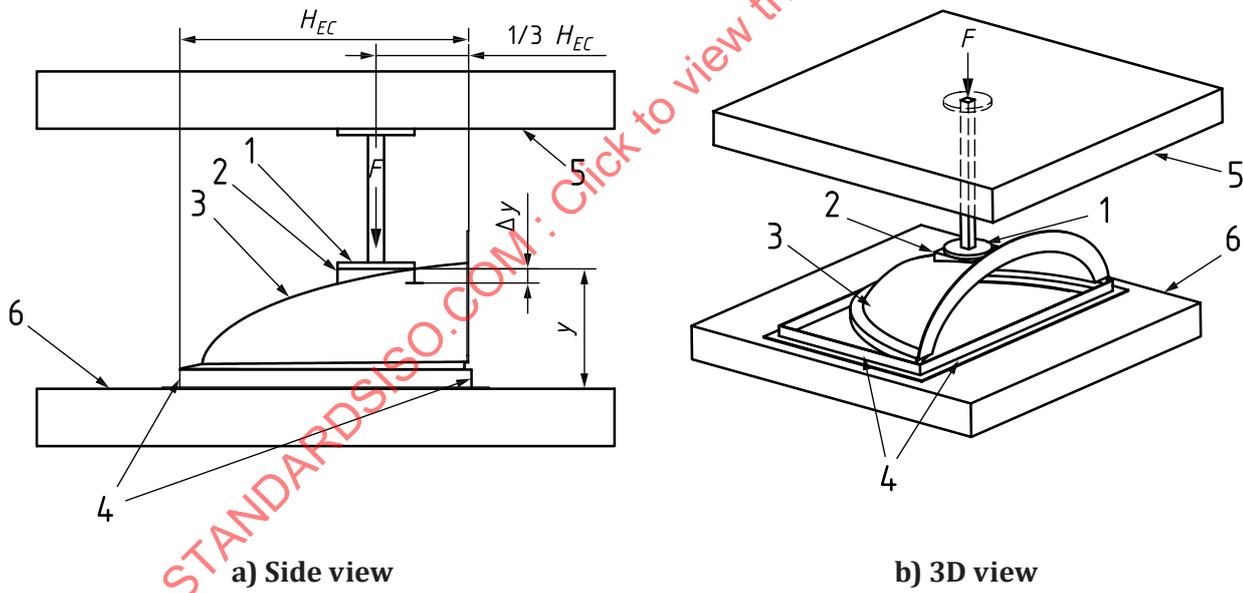
Record flattening observations. End caps shall show neither splitting, cracking, nor breaking under normal light and the unaided eye nor loss of load capacity at 4 % deflection.

## C.8 Test report

The test report shall include the following information:

- a) a reference to this document and this annex, i.e. ISO 4982:2023, Annex C;
- b) a complete description, source and identification of the test piece, including manufacturer's code, manufacturer's product identification and resin type;

- c) the test conditions and conditioning procedures;
- d) the dimensions of each test piece;
- e) the test temperature
- f) the average load rate throughout the test duration;
- g) the loading area;
- h) the maximum load reached during the test, which is the end cap stiffness in kN;
- i) the load versus displacement diagram for the test;
- j) the accuracy grading of the test machine in accordance with ISO 9969;
- k) the end cap stiffness constant (CSC) (according to [Clause C.7](#));
- l) pass or fail at 4 % deflection and flattening observations;
- m) the number of the test pieces;
- n) any factors which may have affected the results, such as any incidents or any operating details not specified in this annex;
- o) any unusual features observed;
- p) the date of measurement.



**Key**

- 1 force application plate
- 2 timber wedge
- 3 end cap
- 4 continuous full perimeter restraint
- 5 upper plate
- 6 lower plate
- $H_{EC}$  height of end cap
- $\Delta y$  deflection

**Figure C.1 — Test piece in position at the start of the test**

## Annex D (normative)

### Stub compression strength test

#### D.1 General

This test method is for the determination of stub compression strength of thermoplastic arch-shaped chamber walls. It is used for the determination of both load capacity for a specified loading rate and short-term compression strain limit.

#### D.2 Principle

A corrugated sample from a chamber wall as shown in [Figure D.1](#) is cut to a specified chord length with parallel surfaces and compressed between two rigid plates at a controlled rate. The sample has a longitudinal length of at least two periods and a chord length of 1,5 times the corrugation height.

Force, displacement of the plates, and time are recorded. The test measures force and displacement versus time to obtain the maximum sustainable force per unit length and maximum strain of the test piece at a specified constant compression displacement rate.

The test data provides the stub compression strength of the chamber wall for the specific test displacement rate and the strain limit of the chamber wall.

#### D.3 Apparatus

The apparatus shall conform in principle to the drawing in [Figure D.2](#). A parallel plate compression testing machine is used to conduct the test. The plates shall be flat, smooth and clean, and shall be sufficiently thick such that no bending or deformation of the plates occurs during the test.

In all other respects, the test machine, force and deflection measuring systems shall conform to the requirements of ISO 604.

#### D.4 Preparation of test pieces

The test pieces shall be taken from the design controlling wall section, which is the lowest part of the wall at the foot. Test pieces shall be cut with the ends flat and parallel to each other within 1° and to the radial line through the centre of the test piece, strictly horizontally from a finished chamber product in accordance with [Figure D.1](#). The test piece longitudinal length should be preferably three periods; the minimum test piece longitudinal length shall be two periods.

The test piece chord length shall be 1,5 times the profile height with a tolerance of 6 mm. The ends shall be cut flat and be free of burrs and jagged edges and parallel to each other. Test pieces are composed of thin elements and are very flexible; therefore, clamping and care are required to produce parallel ends for loading between the parallel plates.

#### D.5 Procedure

##### D.5.1 Conditioning

The conditioning of test pieces shall conform to the requirements of ISO 604.

## D.5.2 Temperature

The test temperature shall conform to the requirements of ISO 604.

## D.5.3 Measurement of test piece dimensions

Determine the profile height of each test piece to the nearest 1,5 mm by making three measurements equally spaced along the longitudinal length. Use the average of the three measurements as the corrugation height. Determine the chord length of each test piece to the nearest 1,5 mm by making three measurements equally spaced along the longitudinal length. Use the average of the three measurements as the chord length.

Determine the longitudinal length of each test piece to the nearest 1,5 mm by making three measurements equally spaced over the chord length. Use the average of the three measurements as the longitudinal length.

Determine the measured wall thickness by making at least three measurements with a micrometre or calibrated non-destructive measuring device on each crest, valley and web of the test piece. Use the average of all thickness measurements as the measured wall thickness.

Equipment for measuring the test piece length and thickness shall conform to the requirements of ISO 604.

## D.5.4 Mounting the test pieces

Place the test piece on the lower plate of the testing machine, centring the test piece under the testing machine crosshead vertical axis.

## D.5.5 Force application procedure

With the external displacement rate indicator in place, start recording the force displacement rate and time continuously (at a data rate of at least 2 Hz) and bring the upper plate into contact with the test piece with no more than a 100 N preload force.

Compress the test piece at a constant cross-head displacement rate of  $1,0 \pm 0,1$  mm/min, continuing to record the force, displacement and time synchronously.

Stop the test when the force fails to increase with increasing cross-head displacement.

## D.6 Calculation and expression of results

Zero force is taken to be the preload force. Identify from the recorded data the maximum additional force applied to the sample and the difference in displacement measured by the external displacement sensor between preload force and maximum force.

Calculate the ultimate compressive load capacity per unit length of corrugation wall as the maximum load (N) divided by the average longitudinal length (mm).

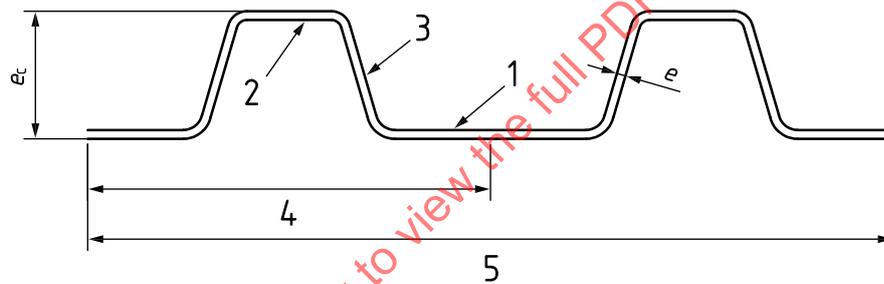
Calculate the short-term compression strain limit by dividing the measured displacement by the starting chord length and report as % strain.

## D.7 Test report

The test report shall include the following information:

- a) a reference to this document and this annex, i.e. ISO 4982:2023, Annex D;
- b) a complete description, source and identification of the chamber test piece, including manufacturer's code, manufacturer's product identification and resin type;

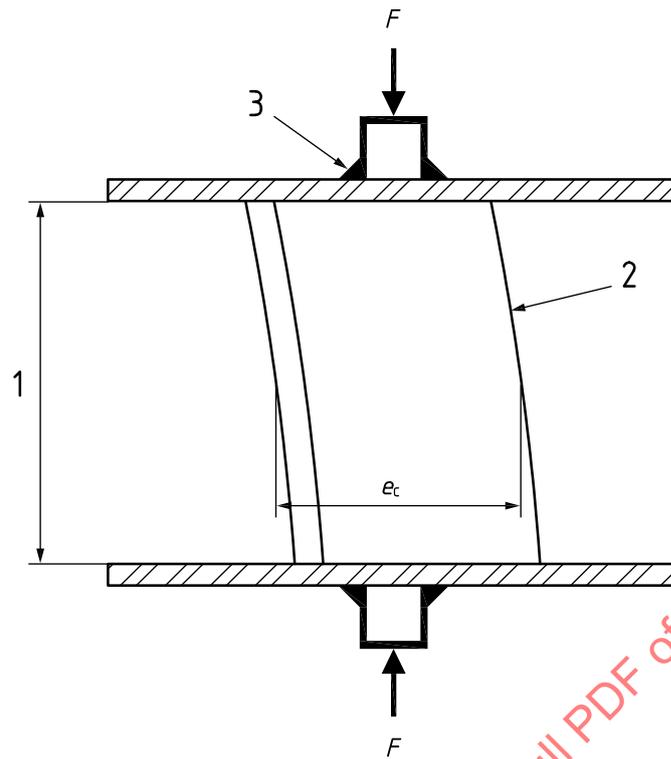
- c) the test conditions and conditioning procedures;
- d) the dimensions of each test piece, including corrugation height, chord length, longitudinal length, and measured wall thickness;
- e) the test temperature;
- f) the force vs. time, displacement vs. time, and displacement rate vs. time;
- g) the maximum force and displacement reached during the test and the time at which it occurred;
- h) the strain limit of the test piece;
- i) the force versus displacement diagram for the test;
- j) the number of pieces tested;
- k) any factors which may have affected the results, such as any incidents or any operating details not specified in this annex;
- l) any unusual features observed;
- m) the date of measurement.



**Key**

- 1 valley
- 2 crest
- 3 web
- 4 period
- 5 minimum sample length

**Figure D.1 — Minimum sample length (two periods)**



**Key**

- 1 chord length
- 2 chamber corrugation test piece
- 3 fixed end plates

**Figure D.2 — Apparatus**

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## Annex E (normative)

### Stub creep testing under compression

#### E.1 General

This test method is for the determination of the creep behaviour of thermoplastic chamber walls under compression with 3 different load levels. Load levels are related to potential loads on the installed chambers, i.e. to cover and width of the chambers.

#### E.2 Principle

The general test set up is similar to the stub compression test in [Annex D](#), except that, for creep testing, a constant force is applied and creep displacement measured over time.

NOTE This test only measures the creep of the wall material and is not representative of the installed arch-chamber total creep which includes any change in the arch shape due to creep and the additional bending stresses in the arch.

The forces applied during the test are selected to be representative of actual service conditions for the chamber being tested and scale with the chamber span, cover mass density and maximum cover depth of the installed system.

Load duration is 1 008 h.

The test reveals displacement versus time.

The data is used for an extrapolation of deflection after 2 years, using the same statistical approach as ISO 9967.

#### E.3 Apparatus

The apparatus shall conform to the test method in [Annex D](#).

#### E.4 Preparation of test pieces

The preparation of test pieces shall conform to the test method in [Annex D](#).

#### E.5 Measurement of test piece dimensions

The preparation of test pieces shall conform to the test method in [Annex D](#).

#### E.6 Conditioning

The conditioning of test pieces shall conform to ISO 9967.

## E.7 Test procedure

### E.7.1 Test temperature

The test temperature shall conform to the requirements of ISO 9967.

### E.7.2 Calculation of load levels

The 3 applied forces are calculated as follows.

Calculate the maximum applied force  $F_1$  (N/mm) according to [Formula \(E.1\)](#):

$$F_1 = 0,5 \cdot S \cdot h \cdot G \quad (\text{E.1})$$

where

$S$  is the span of the chamber, in mm;

$h$  is the maximum cover over the crown of the chamber according to the manufacturer's installation manual, in mm;

$G$  is the average weight of soil, in  $\text{N}/\text{mm}^3$ , which can be assumed by default as  $20 \cdot 10^{-6} \text{ N}/\text{mm}^3$ .

Calculate the two other force levels,  $F_2$  and  $F_3$ , as  $F_2 = 0,8 \cdot F_1$  and  $F_3 = 0,6 \cdot F_1$ , accordingly.

### E.7.3 Mounting of test piece

The mounting of test pieces shall conform to the test method in [Annex D](#).

### E.7.4 Force application

Apply a pre-load force of 100 N. Within 5 min, apply the forces as defined in [E.7.2](#) within (20 - 30) s. Data points shall be generated in accordance with ISO 9967:2016, 8.6.

## E.8 Calculation and expression of results

Extrapolate all deflections to 2 years according to ISO 9967.

Calculate the creep ratios,  $\varphi$ , for all 3 load levels by dividing the extrapolated deflection at 2 years by the deflection at 6 minutes.

Calculate the creep ratio  $\varphi_{0,25}$  at 25 % of stub compression strength per chamber width by relating to the strength as reported in [Annex D](#).

The ratio  $\varphi_{0,25}$  is determined with the equation for the ordinary least squares best straight line to data of creep ratio depending on percentage of strength. The line is defined in accordance with ISO/TS 28037:2010, 5.8, with % of stub compression strength as  $x$  and creep ratio as  $y$ .

## E.9 Test report

The test report shall include the following information:

- a) a reference to this document and this annex, i.e. ISO 4982:2023, Annex E;
- b) a complete description, source and identification of the test piece and the chamber from which it was taken, including manufacturer's code, manufacturer's product identification and resin type;
- c) the test conditions and conditioning procedures;

- d) the dimensions of each test piece, including corrugation height, chord length, longitudinal length, and measured wall thickness;
- e) the test temperature;
- f) the pre-load (contact) force applied and the applied force vs. time for each test;
- g) measured creep displacement or creep strain vs. log<sub>10</sub> time for each test;
- h) the calculations of creep ratios for each test including:
  - equations  $Y = B + M \log t$  used for extrapolation to the two-year deflection point for each test piece;
  - correlation coefficient in each case; points used for the linear regression analysis;
  - calculated values of creep ratio for each applied force and the calculated value of the creep ratio rounded to two significant figures.;
- i) the calculation of the creep ratio at 25 % of stub compression strength per chamber width ([Clause E.8](#));
- j) any factors which may have affected the results, such as any incidents or any operating details not specified in this annex;
- k) any unusual features observed;
- l) the date of measurement.

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