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Plastics piping systems for drainage and sewerage without pressure — Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) — Dimensions, requirements and tests

Systèmes de canalisation en plastiques pour réseaux d'assainissement sans pression — Tuyaux non-circulaires, assemblages de tuyaux et raccords en plastiques thermodurcissables renforcés de verre (PRV) à base de résines de polyester non saturé (UP) — Dimensions, exigences et essais

Reference number
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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).

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).

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

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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 6, *Reinforced plastics pipes and fittings for all applications*.

Introduction

The goal to establish this product standard is to standardize the requirements for non-circular GRP pipes.

This document specifies the requirements for non-circular GRP pipe systems, designed to be used for the renovation of existing channels or open cut installation.

This document specifies dimensions, requirements and tests of non-circular pipes including short and long-term properties. To establish long-term properties, it is recommended to use the circular pipes samples.

Annex A shows commonly used calculation methods but only as information. The calculation method is selected by the designer.

This document does not include the recommended practice for installation as this should be a separate document.

Plastics piping systems for drainage and sewerage without pressure — Non-circular pipes and joints made of glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resins (UP) — Dimensions, requirements and tests

1 Scope

This document specifies the required properties of the piping system and its components made from glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) intended to be used for drainage or sewerage without pressure including culverts.

It is the responsibility of the purchaser or specifier to make the appropriate selections taking into account their particular requirements and any relevant national regulations and installation practices or codes.

This document is applicable to non-circular GRP-UP pipes, with flexible or rigid joints, primarily intended for use in buried installations but may also be used to reline existing non-circular pipe lines.

NOTE 1 GRP-UP includes pipes with vinyl ester liners or made entirely from vinyl ester.

NOTE 2 Piping systems conforming to this document can be used also for non-buried applications provided the influence of the environment, e.g. from UV-radiation, and the supports are considered in the design of the pipes, fittings and joints.

This document is applicable to pipes, fittings and their joints of nominal sizes from DN 150 to DN 4000, which are intended to be used for the conveyance of surface water or sewage at temperatures up to 50 °C.

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 75-2:2013, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite*

ISO 178, *Plastics — Determination of flexural properties*

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

ISO 4633, *Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials*

ISO 8513:2016, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the initial longitudinal tensile strength*

ISO 8533, *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Test methods to prove the design of cemented or wrapped joints*

ISO 8639, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Test methods for leaktightness and proof of structural design of flexible joints*

ISO 10468, *Glass-reinforced thermosetting plastics (GRP) pipes — Determination of the long-term specific ring creep stiffness under wet conditions and calculation of the wet creep factor*

ISO 10928, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

ISO 10952, *Plastics piping systems — 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*

EN 681-1, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*

EN/TS 14632, *Plastics piping systems for drainage, sewerage and water supply, pressure and non-pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Guidance for the assessment of conformity*

3 Terms and definitions

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

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

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

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

3.1
nominal size
BN × *HN*
alphanumerical designation of size, which is common to all components in a piping system, it is a convenient pair of numbers for reference purposes that is related to the maximum internal breadth (*B*) and the maximum internal height (*H*)

Note 1 to entry: The designation for reference or marking purposes consists of the letters *BN*(*B*) × *HN*(*H)* and the numerical values for (*B)* and (*H)*, when expressed in millimetres.

3.2
declared dimensions
dimensions which a manufacturer states to be the internal breadth (*B*) and height (*H*) produced in respect of a particular nominal size *BN* × *HN*

3.3
specific ring stiffness
S
physical characteristic of a circular pipe which is a measure of the resistance to ring deflection per metre length under external load

Note 1 to entry: Specific ring stiffness is determined using formula below and is expressed in Newtons per square metre (N/m^2):

$$S = \frac{E \cdot I}{d_m^3}$$

where

E is the apparent modulus of elasticity, which can be derived from the result of the ring stiffness test, i.e. ISO 7685, expressed in Newtons per square metre (N/m^2);

d_m is the mean diameter of the pipe, in metres (m) (see 3.5);

I is the second moment of area in the longitudinal direction per metre length, in metres to the fourth power per metre, (m^4/m):

$$I = \frac{e^3}{12}$$

where

e is the wall thickness, in metres.

3.4
initial specific ring stiffness

S_0

value of S obtained when a circular pipe is tested in accordance with ISO 7685

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

3.5
mean diameter

d_m

diameter of the circle corresponding with the middle of a circular pipe wall cross section

Note 1 to entry: Mean diameter is derived using the formula with the inside diameter and wall thickness expressed in metres (m):

$$d_m = ID + e$$

where

e is the pipe's wall thickness.

3.6
wet creep factor

$\alpha_{x,\text{creep,wet}}$

ratio of the long-term specific ring stiffness, $S_{x,\text{wet}}$ to the initial specific ring stiffness, S_0 at x years

Note 1 to entry: See 4.4.6 for value of x.

Note 2 to entry: Determined using circular test-pieces under sustained diametrical loading in wet conditions when tested in accordance with ISO 10468.

Note 3 to entry: Wet creep factor is a dimensionless number given by the formula:

$$\alpha_{x,\text{creep,wet}} = \frac{S_{x,\text{wet}}}{S_0}$$

3.7
long-term specific ring stiffness

$S_{x,\text{wet}}$

determined value of specific ring stiffness S at x years for circular pipe

3.8
rerating factor

R_{RF}

multiplication factor that quantifies the relationship of a product's mechanical, physical and chemical properties under service conditions above 35 °C [*design service temperature* (3.16)] to those applicable at a standard test temperature of 23 °C

3.9
short term bending strength
σ_f
maximum flexural stress sustained by the test specimen during a bending test, when tested in accordance with ISO 178

Note 1 to entry: Short-term bending strength is determined using the following formula and is expressed in megapascals (MPa):

$$\sigma_f = \frac{3FL}{2bh^2}$$

where

σ_f is the flexural stress, in megapascals (MPa);

F is the load in newtons (N);

L is the span, in millimetres (mm);

h is the thickness of the specimen, in millimetres (mm);

b is the width of the specimen, in millimetres (mm).

3.10
long-term bending strength
σ_{fx}
calculated value of σ_f at x years for circular pipe

Note 1 to entry: Long-term bending strength is determined using methodology given in 5.2.5.3, using linear regression analysis according to ISO 10928 on data of bending stress in hoop direction, and is expressed in megapascals (MPa):

$$\sigma_{circ} = \frac{6 \cdot f\max \cdot \frac{d_m}{2} \cdot \frac{1}{\pi}}{l \cdot e^2} \cdot \alpha_{ki}$$

with

$$\alpha_{ki} = \frac{3 \cdot d_i + 5 \cdot e}{3 \cdot d_i + 3 \cdot e}$$

where

σ_{circ} is the ring bendning stress, in megapascals (MPa);

F_{max} is the maximum force, in newtons (N);

d_m is the mean diameter, in millimetres (mm);

d_i is the inside diameter, in (mm);

e is the structural wall thickness, in (mm);

l is the length of specimen, in (mm);

α_{ki} is the correction factor inner surface.

3.11
short term bending modulus
E_f
value of flexural modulus obtained when tested in accordance with ISO 178

Note 1 to entry: Short term bending modulus is determined using the following formula and is expressed in megapascals (MPa):

$$E_f = \frac{L^3}{4b \cdot h^3} \cdot \frac{F_{max}}{s_{max}}$$

where

E_f is bending modulus, in megapascals (MPa);

F_{max} is the maximum force corresponds to maximum deflection, in newtons (N);

s_{max} is the maximum deflection of specimen , in millimetres (mm);

b is the width specimen width, in (mm);

h is the wall thickness of the specimen, in (mm);

L is the span, in (mm).

3.12
long-term creep bending modulus
E_{fx}
calculated value of E_f at x years for circular pipe when tested in accordance with ISO 10468

Note 1 to entry: Long-term bending modulus is determined using the following formula and is expressed in megapascals (MPa):

$$E_{fx} = E_0 \cdot \alpha_{x,\text{creep,wet}}$$

where

E_{fx} is the long-term creep bending modulus, in megapascals (MPa);

E_0 is the short-term bending modulus as result of the creep test on circular profiles according to ISO 10468, in megapascals (MPa);

$\alpha_{x,\text{creep,wet}}$ is the wet creep factor, see 3.6.

3.13
type tests
tests carried out to prove that a material, component, joint or assembly is capable of conforming to the relevant requirement

3.14
laying length
total length of a pipe minus, where applicable, the manufacturer's recommended insertion depth of the spigot(s) in the socket

Note 1 to entry: Laying length is expressed in metres (m).

3.15
normal service conditions
conveyance of surface water or sewage, in the temperature range 2 °C to 50 °C, with maximum water table of 10 m, for 50 years

3.16
design service temperature
maximum sustained temperature at which the system is expected to operate

Note 1 to entry: Expressed in degrees Celsius (°C).

3.17
flexible joint
joint which allows relative movement between the pipes being joined

Note 1 to entry: Examples of this type of joint are: socket-and-spigot joint with an elastomeric sealing element (including double socket designs)

3.18
rigid joint
joint which does not allow relative movement between the pipes being joined

Note 1 to entry: Examples of this type of joint are: flanged joint, including integral and loose flanges, wrapped or cemented joint.

3.19
angular deflection
δ
angle between the axes of two adjacent pipes

Note 1 to entry: See Figure 1.

Note 2 to entry: Angular deflection is expressed in degrees (°).

3.20
draw
D
longitudinal movement of a joint

Note 1 to entry: See Figure 1.

Note 2 to entry: Draw is expressed in millimetres (mm).

3.21
total draw
T
sum of the draw, *D*, and the additional longitudinal movement, *J*, due to the presence of angular deflection

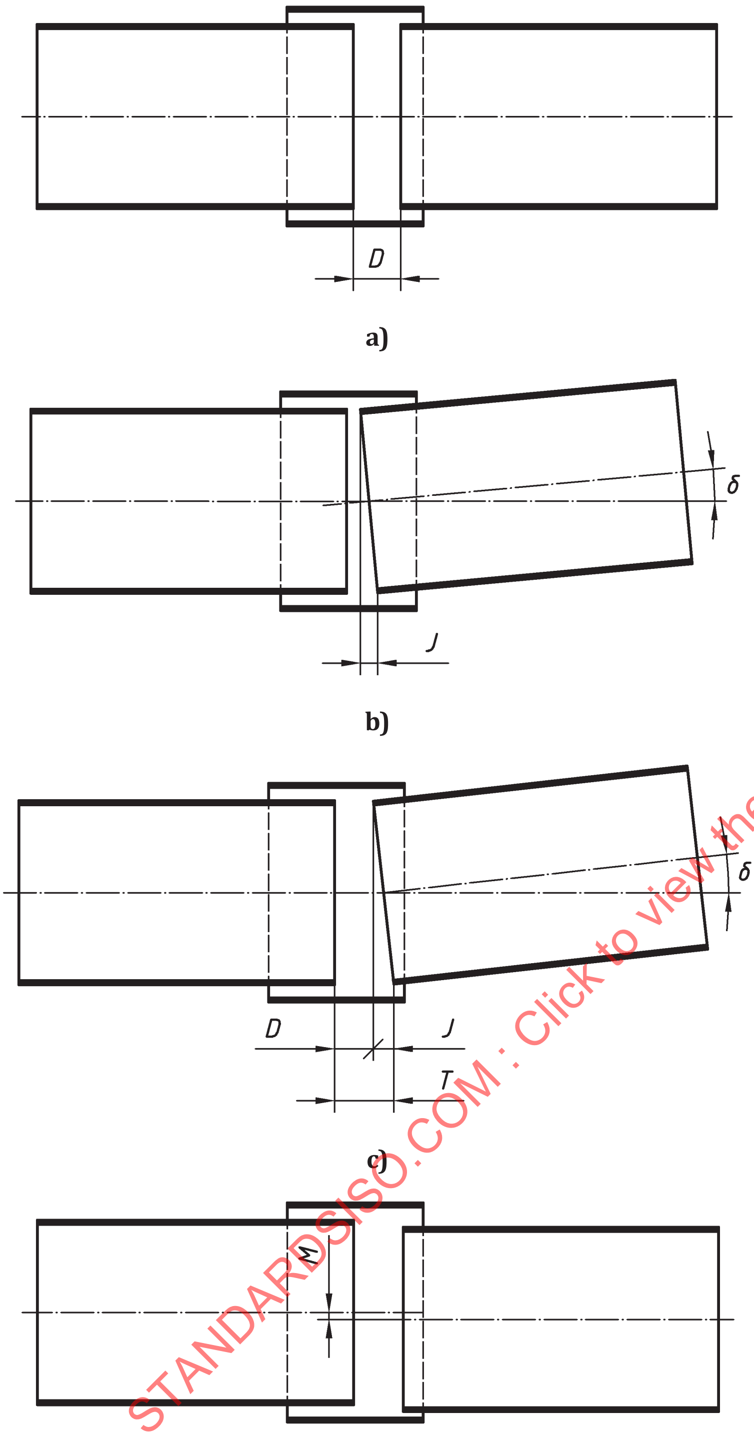
Note 1 to entry: See Figure 1.

Note 2 to entry: Total draw is expressed in millimetres (mm).

3.22
misalignment
M
amount by which the centrelines of adjacent pipes fail to coincide

Note 1 to entry: See Figure 1.

Note 2 to entry: Misalignment is expressed in millimetres (mm).



Key

D draw

J longitudinal movement arising from angular deflection of the joint

δ angular deflection of the joint

T total draw

M misalignment

Figure 1 — Joint movement

4 General requirements

4.1 Classification

4.1.1 Categories

Pipes conforming to this document shall be classified according to nominal size (*BN* × *HN*) (see 3.1), and joint type i.e. flexible or rigid (see 3.17 or 3.18).

4.1.2 Nominal size

The nominal size (*BN* × *HN*) (see 3.1) of pipes shall conform to the product declaration of the manufacturer.

4.2 Materials

4.2.1 General

The pipe shall be constructed using chopped and/or continuous glass filaments, strands or rovings, mats or fabric synthetic veils, and polyester resin with or without fillers and if applicable additives necessary to impart specific properties to the resin. The pipe or fitting may also incorporate aggregates, and if required a thermoplastic liner.

4.2.2 Reinforcement

The glass used for the manufacture of the reinforcement shall be one of the following types:

a) type "E" glass, comprising primarily either oxides of silicon, aluminium and calcium (alumino–calcosilicate glass) or silicon, aluminium and boron (alumino-borosilicate glass);

b) type "C" glass, comprising primarily oxides of silicon, sodium, potassium, calcium and boron (alkali metal calcium glass with an increased boron trioxide content) which is intended for applications requiring enhanced chemical resistance;

c) type "R" glass, comprising primarily oxides of silicon, aluminium, calcium and magnesium without added boron;

d) type "E-CR" glass, comprising boron-free modified E-glass compositions for improved resistance to corrosion by most acids.

In any of these types of glass small amounts of oxides of other metals will be present.

NOTE These descriptions for "C" glass and "E" glass are consistent with, but more specific than those given in ISO 2078.

The reinforcement shall be made from continuously drawn filaments of a glass conforming to type E, type C or type R, and shall have a surface treatment compatible with the resin to be used. It may be used in any form, e.g. as continuous or chopped filaments, strands or rovings, mat or fabric.

4.2.3 Resin

The resin used in the structural layer (see 4.3.2) shall have a temperature of deflection of at least 70 °C when tested in accordance with ISO 75-2:2013, method A with the test specimen in the edgewise position.

NOTE Resins can be unsaturated polyesters or based on vinyl esters.

4.2.4 Aggregates and fillers

The size of particles in aggregates and fillers shall not exceed 1/5 of the total wall thickness of the pipe or 2,5 mm, whichever is the lesser.

4.2.5 Elastomers

Each elastomeric material(s) of the sealing component shall conform to the applicable requirements of EN 681-1 or ISO 4633.

NOTE ISO 4633 is equal to EN 681-1 and gaskets complying with these standards are deemed to satisfy the 50 years design life of the pipe systems made in accordance with this document.

4.2.6 Metals

Where exposed metal components are used, there shall not be evidence of corrosion of the components after the fitting has been immersed in an aqueous sodium chloride solution, 30 g/l, for 7 d at (23 ± 2) °C.

4.3 Wall construction

4.3.1 Inner layer

The inner layer shall comprise one of the following:

a) a thermosetting resin layer with or without aggregates or fillers and with or without reinforcement of glass or synthetic filaments;

b) a thermoplastics liner.

The thermoplastic liner may require a bonding material compatible with all other materials used in the pipe construction.

The resin used in this inner layer need not conform to the temperature of deflection requirements given in 4.2.3.

NOTE The construction of the liner influences the chemical and abrasion resistance of the pipe.

4.3.2 Structural layer

The structural layer shall consist of glass reinforcement and a thermosetting resin, with or without aggregates or fillers.

4.3.3 Outer layer

The design of the outer layer of the pipe shall take into account the environment in which the pipe is to be used. This layer shall be formed of a thermosetting resin with or without aggregates or fillers and with or without a reinforcement of glass or synthetic filaments.

The use of special constructions is permitted when the pipe is expected to be exposed to extreme climatic, environmental or ground conditions, for example, provision for the inclusion of pigments or inhibitors for extreme climatic conditions or fire retardation.

The resin used in this outer layer need not conform to the temperature of deflection requirements in 4.2.3.

4.3.4 Appearance

Both internal and external surfaces shall be free from irregularities, which would impair the ability of the component to conform to the requirements of this document.

4.4 Reference conditions for testing

4.4.1 Temperature

The mechanical, physical and chemical properties specified in all clauses of this document shall, unless otherwise specified, be determined at (23 ± 5) °C.

For service temperatures over 35 °C, type tests (see 3.10) shall be carried out at least at the design service temperature to establish re-rating factors, R_{RF} (see 3.8) for all long-term properties of relevance to be used in the design of pipes and fittings.

4.4.2 Properties of water for testing

The water used for the tests referred to in this document shall be tap water having a pH of 7 ± 2.

4.4.3 Loading conditions

Unless otherwise specified, the mechanical, physical and chemical properties specified in all clauses of this document shall be determined using circumferential and/or longitudinal loading conditions, as applicable.

4.4.4 Conditioning

Unless otherwise specified, in case of dispute store the test piece(s) in air at the test temperature specified in 4.4.1 for at least 24 h prior to testing.

4.4.5 Measurement of dimensions

In case of dispute, the dimensions of GRP-UP components shall be determined at the temperature specified in 4.4.1. Measurements shall be made in accordance with ISO 3126 to determine conformity or otherwise to the applicable limits. Routine measurements shall be determined at the prevailing temperature or if the manufacturer prefers at the temperature specified in 4.4.1.

4.4.6 Elapsed time for determination of long-term properties, (x)

The subscript x, in for example $S_{x,\mathrm{wet}}$ (see 3.8), denotes the elapsed time for which the long-term property is to be determined. Unless otherwise specified, the long-term properties shall be determined at 50 years (438 000 h).

4.5 Joints

4.5.1 General

The manufacturer shall declare the length and the maximum external dimension of the assembled joint.

4.5.2 Types of joint

A joint shall be classified as either flexible (see 3.17) or rigid (see 3.18) and in each case whether or not it is capable of resisting end-loads.

4.5.3 Flexibility of the jointing system

4.5.3.1 Allowable maximum angular deflection

The manufacturer shall declare the allowable maximum angular deflection for which each joint is designed and about which axis (B or H) the rotation occurs.

4.5.3.2 Maximum draw

The manufacturer shall declare the maximum draw (see 3.20) for which each joint is designed.

For flexible joints, the maximum draw, which includes the Poisson contraction and temperature effects, shall not be less than 0,2 % of the laying length (see 3.14) of the longest pipe with which it is intended to be used.

4.5.4 Sealing ring

The sealing ring shall not have any detrimental effect on the properties of the components with which it is used and shall not cause the test assembly to fail the functional requirements of Clause 6.

4.5.5 Adhesives

Adhesives, if required for jointing, shall be specified by the manufacturer of the joint. The joint manufacturer shall ensure that the adhesives shall not have any detrimental effects on the components with which it is used and shall not cause the test assembly to fail the functional requirements of Clause 6.

5 Pipes

5.1 Geometrical characteristics

5.1.1 Dimensions

Non-circular pipe profiles are available with various kinds of shapes (see Figure 2) and are designed individually depending on their use, required hydraulic capacity and the static load they need to resist.

NOTE It will be the responsibility of the manufacturer to demonstrate to the purchaser the applicability of the design basis used to determine the profile dimensions, wall thickness and laminate design to adequately resist the loads applied in the intended application.

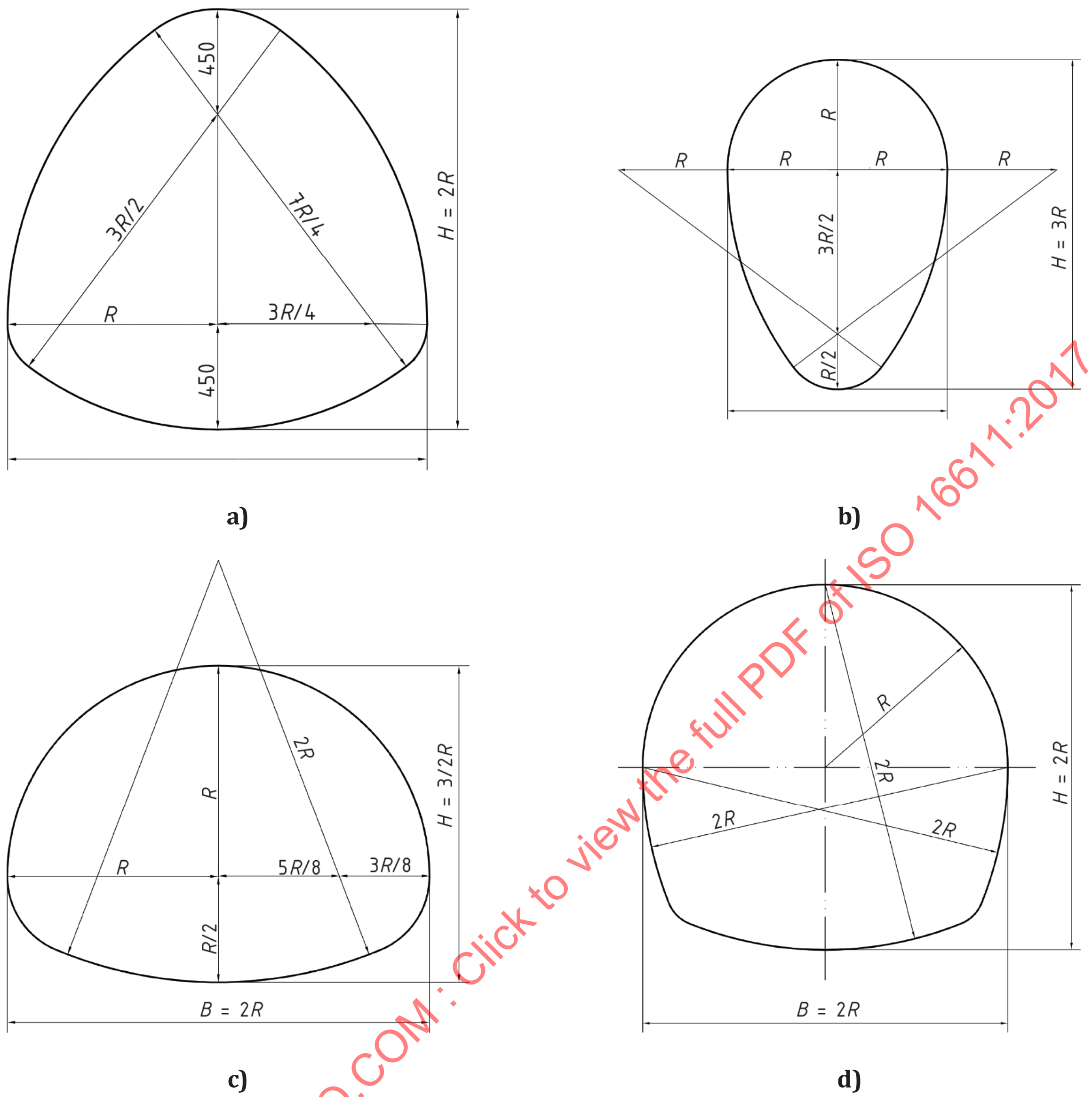


Figure 2 — Typical pipe profile shapes

The external dimensions of pipe profiles, as well as their overall length shall be agreed between the manufacturer and the client. Any measured wall thicknesses shall be equal to or exceed the minimum required wall thickness previously agreed between the manufacturer and client.

The laying length (see 3.14) shall comply with the agreed laying length subject to a tolerance of +20 mm and −10 mm.

5.2 Mechanical characteristics

5.2.1 General

When determining the mechanical properties of the structural layer, e.g. the calculation of E-modulus, tensile strength, etc., the thickness of outside and inside layers (e.g. liners) shall be measured and they shall be deleted from the measured wall thickness and the property being determined is to be based on the structural layer only.

Because of the problems arising from the wide range of strain conditions across all of the possible profile shapes it is preferable to determine the long-term mechanical characteristics of the laminate using test pieces cut from circular samples made having the same layer construction and the same production conditions as a non-circular pipes.

To determine long-term properties as mentioned in Clause 5, circular pipes shall be manufactured under the same condition as non-circular pipes (manufactured by the same process) and having the same wall construction as a non-circular pipes (the sequence of layers, layer compositions, material properties and design method). The manufacturer shall establish in their quality system product grouping in reference to EN/TS 14632.

NOTE While circular flexible pipes are classified by stiffness this is not meaningful for non-circular pipes but may be determined incidentally for a circular sample pipes during testing. It is more meaningful to derive the product EI from such tests as this property will the basis of any analysis to determine the structural capability of a non-circular pipe.

5.2.2 Short-term bending modulus

5.2.2.1 General

The determination of the short-term bending modulus shall be carried out by means of the three-point bending test based on ISO 178 with at least five rectangular test specimens who shall conform to 5.2.2.5.

Calculate the short-term bending modulus using the formula in 3.11.

ISO 178 is designed for use with straight samples and some inaccuracies could occur with increasing curvature as with samples cut from smaller diameters. In order to minimize the inaccuracies caused by the sample curvature, it is recommended to cut specimens from sections with the largest profile radius.

In the case of a non-circular pipe represented by Figure 2 d), the so-called horseshoe-shaped pipe, having an inner height and an inner width equal to $2R$ (R is a radius of the semi-circular portion), the test described in this subclause may be replaced with a stiffness test using a full non-circular ring. When the geometry of the horse-shoe-shaped pipe is changed, however, the horseshoe-shaped pipe shall be tested again to prove a correlation between a circular pipe manufactured with the same wall construction.

5.2.2.2 Requirements

When tested in accordance with ISO 178, the value of short-term bending modulus shall be not less than the value declared by the manufacturer.

5.2.2.3 Number of test piece for type testing

When testing in accordance with ISO 178, cut 10 rectangular-shaped test pieces from each of three different pipes of the same nominal size.

5.2.2.4 Number of test piece for quality control test purposes

When testing in accordance with ISO 178, five rectangular-shaped test pieces of one pipe shall be used.

5.2.2.5 Dimensions of test pieces

This test shall be performed using at least five test pieces cut out of the sample circumferentially. In order to achieve results within the limits of measurement accuracy, the outside surface may, if necessary, be evened by grinding.

The dimension of the test pieces shall be the following:

— width of test piece shall comply with the requirements of ISO 178;

— length of test piece shall be = 20 × structural wall thickness;

— span of test piece shall be = 16 × structural wall thickness.

5.2.3 Long-term creep bending modulus

5.2.3.1 General

The determination of the long-term creep bending modulus shall be carried out on the full circular test pieces according to ISO 10468 using the calculated wet creep factor $\alpha_{x,\text{creep,wet}}$ and calculated short-term bending modulus E_0, see 3.12.

Calculate the long-term creep bending modulus using the formula in 3.12.

5.2.3.2 Method of test to determine $\alpha_{x,\text{creep,wet}}$ and E_0

Determine the wet creep factor and the short-term bending modulus of the test pieces in accordance with ISO 10468 using test pieces conforming to 5.2.3.

5.2.3.3 Requirements

The value of long-term creep bending modulus shall be not less than the value declared by the manufacturer.

5.2.3.4 Number of test piece for type testing

Use two test pieces of the same size and classification and of length, L_p, conforming to 5.2.3.5.

5.2.3.5 Dimensions of test pieces

The length, L_p, of the test piece shall be 0,3 m ± 5 % for all nominal sizes.

5.2.4 Short-term bending strength

5.2.4.1 General

The determination of the short-term bending strength shall be carried out by means of the three-point bending test based on ISO 178 with at least five rectangular-shaped test specimens who shall conform to 5.2.4.5.

Calculate the short-term bending strength using the formula in 3.9.

ISO 178 is designed for use with straight samples and some inaccuracies could occur with increasing curvature as with samples cut from smaller diameters. In order to minimize the inaccuracies caused by the sample curvature, it is recommended to cut specimens from sections with the largest profile radius.

In the case of a non-circular pipe represented by Figure 2 d), the so-called horseshoe-shaped pipe, having an inner height and an inner width equal to $2R$ (R is a radius of the semi-circular portion), the test described in this subclause may be replaced with a stiffness test using a full non-circular ring. When the geometry of the horse-shoe-shaped pipe is changed, however, the horseshoe-shaped pipe shall be tested again to prove a correlation between a circular pipe manufactured with the same wall construction.

5.2.4.2 Requirements

When tested in accordance with ISO 178, the value of short-term bending strength shall be not less than the value declared by the manufacturer.

5.2.4.3 Number of test piece for type testing

When testing in accordance with ISO 178, cut 10 rectangular-shaped test pieces from each of three different pipes of the same nominal size.

5.2.4.4 Number of test piece for quality control test purposes

When testing in accordance with ISO 178, five rectangular-shaped test pieces of one pipe shall be used.

5.2.4.5 Dimensions of test pieces

This test shall be performed using at least five test pieces cut out of the sample circumferentially. In order to achieve results within the limits of measurement accuracy, the outside surface may, if necessary, be evened by grinding.

The dimension of the test pieces shall be the following:

— width of test piece shall comply with the requirements of ISO 178;

— length of test piece shall be = 20 × structural wall thickness;

— span of test piece shall be = 16 × structural wall thickness.

5.2.5 Long-term bending strength

5.2.5.1 General

The determination of the long-term bending strength shall be carried out on the full circular test pieces according to methodology given in 5.2.5.3

Calculate the long-term bending strength using the formula in 3.10.

NOTE In absence of data, the long-term bending strength in hoop direction may be obtained by multiplying the short-term bending strength in hoop direction with a creep factor, which is determined as the long-term bending modulus in hoop direction, divided by the short-term bending modulus in hoop direction.

5.2.5.2 Requirements

The value of long-term bending strength shall be not less than the value declared by the manufacturer.

5.2.5.3 Methodology to determine long-term bending strength

In order to determine the long-term bending strength in hoop direction of circular GRP specimens using the data obtained in the Strain Corrosion test method (ISO 10952), the following procedure shall be used.

NOTE ISO 10952 does not require the recording of the load, but in the present context it is necessary to calculate the bending strength.

The strain levels, reached by the ring deflection in the strain corrosion tests, are converted into bending stresses (in hoop direction) using the formula in 3.10.

The load F_{max} shall be measured when the specimen is deflected. This may be measured when the sample is fixed in the strain corrosion test rig and placed in a compressive testing machine. By the movement of the crosshead, the sample is deformed uniformly and load is measured. The load for the calculation of the bending stress shall be taken at the desired deflection. The elements shall be deflected at a uniform speed of 2 % per minute, i.e. deflection speed (mm/min) = (0,02 ± 0,002) d_m, with d_m in mm. After the load has been noted, tighten the threaded bars of the strain corrosion test rigs until the load cell of the testing machine is zeroed and perform the long-term test with this deflection.

Linear regression analysis according to ISO 10928 on data log10 (bending stress in hoop direction) in function of log10 (corresponding failure time in strain corrosion test), followed by determination of the 50 years extrapolated value of the bending stress in hoop direction (MPa).

5.2.5.4 Number of test piece for type testing

Use 18 test pieces of the same size and classification and of length, L_p, conforming to 5.2.5.5.

5.2.5.5 Distribution of failure times

The times to failure of the 18 or more specimens shall be distributed between 0,1 and over 10^4 h, and the distribution of 10 of these results shall conform to the distribution given in Table 1.

Table 1 — Failure time distribution

Failure time t_u h	Minimum number of failure values
$10 \leq t_u \leq 1\ 000$	4
$1\ 000 < t_u \leq 6\ 000$	3
$6\ 000 < t_u$	3[a]

[a] At least one of these shall exceed 10 000 h.

Were leak failure cannot be obtained in less than 1 000 h, two of the relevant failure points (see Table 1) shall be obtained additionally between 1 000 h and 6 000 h and the other two additionally over 6 000 h.

When at least 16 of the test pieces have failed under test and the remaining test pieces have been on test for more than 1 000 h, it is permissible for these remaining test pieces to be included in the data used to establish the required extrapolated value.

5.2.5.6 Dimensions of test pieces

The length, L_p, of the test piece shall be 0,3 m ± 5 % for all nominal sizes.

5.2.6 Resistance to strain corrosion

5.2.6.1 General

For pipes intended to be used for septic sewers or the conveyance of corrosive effluents, the strain corrosion resistance shall be determined using the procedure described in ISO 10952. For such tests, representative circular samples of similar wall construction to the proposed product will be required.

NOTE ISO 10952 does not require the recording of the load, but in the present context it is necessary to calculate the bending strength (see 5.2.5.3).

5.2.6.2 Requirements

Tests shall be performed in accordance with ISO 10952 using leak failure as the criteria. From the results, the extrapolated x year deflection shall be obtained using ISO 10928. The extrapolated value shall be declared by the manufacturer.

5.2.6.3 Number of test piece for type testing

Take a sufficient number of test pieces from one or more pipes for at least 18 failure points to be obtained so that the analysis can be carried out using ISO 10928.

5.2.6.4 Dimensions of test pieces

The length, L_p, of the test piece shall be 0,3 m ± 5 % for all nominal sizes.

5.2.7 Minimum initial longitudinal tensile strength

5.2.7.1 General

Determine the initial specific longitudinal tensile strength in accordance with ISO 8513:2016, method A.

NOTE Initial longitudinal tensile strength of the pipe wall is expressed in newton per millimetre of circumference (N/mm).

5.2.7.2 Requirements

When tested in accordance with ISO 8513:2016, method A, the value of the initial longitudinal tensile strength shall not be less than the value given in Table 2, applicable to the maximum dimensions of cross section (MDC) of the pipe under test.

NOTE The maximum dimension of the cross section (MDC) is based on the inner diameter as non-circular profiles are usually specified by the inner diameter.

When pipes having a nominal size different from those given in Table 2, obtain the required minimum initial specific longitudinal tensile strength using Formula (1):

$$\sigma_{LA} \geq 0{,}123 \times \text{MDC} + 57 \quad (1)$$

where

σ_{LA} initial longitudinal tensile strength, in N/mm of circumference;

MDC maximum dimension of cross-section, in mm.

Table 2 — Minimum initial specific longitudinal tensile strength

Maximum dimension of cross section (MDC) mm	**Minimum initial specific longitudinal tensile strength** N/mm of circumference
150	75
200	80
250	85
300	95
400	105
500	120
600	130
700	145
800	155
900	165
1 000	180
1 200	205
1 400	230
1 600	255
1 800	280
2 000	305

Table 2 *(continued)*

Maximum dimension of cross section (MDC) mm	Minimum initial specific longitudinal tensile strength N/mm of circumference
2 200	330
2 400	350
2 600	375
2 800	400
3 000	426
3 200	450
3 400	475
3 600	500
3 800	525
4 000	550

5.2.7.1 Number of test pieces for type testing

When testing in accordance with ISO 8513:2016, method A, cut 10 strip test pieces from each of three different pipes of the same nominal size.

5.2.7.2 Number of test pieces for quality control test purposes

When testing in accordance with ISO 8513:2016, method A five stripe test pieces of one pipe shall be used.

5.2.7.3 Dimensions of test pieces

The dimensions of the test piece shall conform to ISO 8513:2016, method A.

5.3 Marking

Marking details shall be printed or formed directly on the pipe in such a way that the marking does not initiate cracks or other types of failure.

If printing is used, the colouring of the printed information shall differ from the basic colouring of the product and the printing shall be such that the marking is readable without magnification.

The following marking shall be on the outside of each pipe:

a) reference to this document, i.e. ISO 16611;

b) the nominal size *BN* × *HN* and the diameter group, e.g. A or B;

c) the manufacturer’s name or identification;

d) the date of manufacture, in plain text or code;

e) standard quality mark if applicable;

f) description “gravity pipe”.

6 Fittings

6.1 All types

6.1.1 General

Depending on application may be necessary to produce the fittings as, e.g. segmental bends, T-pieces or branches.

6.1.2 Diameter series

The diameter series of the fitting shall be that of the straight length(s) of pipe to which the fitting is to be joined in the piping system.

6.1.3 Mechanical characteristics of fittings

6.1.3.1 General

Fittings shall be designed and manufactured in accordance with relevant design practices.

Laminates shall be designed to carry axial loads and to fulfil minimum longitudinal tensile strength as specified in Table 2.

6.1.4 Installed leak tightness of fittings

Where a specific site installation test is declared by the purchaser or is agreed between the manufacturer and the purchaser, the fitting and its joints shall be capable of withstanding that test without leakage.

6.1.5 Dimensions

The broad design and process flexibility afforded by GRP-UP materials makes it difficult to totally standardize GRP-UP fitting dimensions. The dimensions are to be taken as only indicative of common practice values and it is therefore permissible to use other dimensions. The use of other dimensions does not preclude the components from being covered by this document.

6.2 Marking

Marking details shall be printed or formed directly on the fitting in such a way that the marking does not initiate cracks or other types of failure.

If printing is used, the colouring of the printed information shall differ from the basic colouring of the product and such that the markings shall be readable without magnification.

The following marking shall be on the outside of each fitting:

a) number of this document;

b) the nominal size *BN* × *HN* and the diameter group, e.g. A or B;

c) for angle fittings, the designated fitting angle;

d) manufacturer's name or identification;

e) date or code of manufacture;

f) standard quality mark if applicable.